THE

# FOURTEENTH

# ANNUAL REPORT

OF THE

# MARYLAND

# Agricultural Experiment Station,

COLLEGE PARK,

PRINCE GEORGE'S CO. MARYLAND.



1900-1901.

PUBLISHED BY THE STATION.

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# THE
# Maryland Agricultural Experiment Station.

## CORPORATION.

## THE BOARD OF TRUSTEES OF THE MARYLAND AGRICULTURAL COLLEGE.



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**The Station is Located on the B. & O. R. R. and City & Surburban Electric Car Line, 8 miles north of Washington, D. C.**

Visitors will be welcomed at all times, and will be given every opportunity to inspect the work of the Station in all of its departments.

The Bulletins and reports of the Station, will be mailed regularly, free of charge to all residents of the State who request it.


ADDRESS:

AGRICULTURAL EXPERIMENT STATION,

College Park, Maryland.

## LETTER OF TRANSMITTAL.

*To His Excellency, John Walter Smith,*

*Governor, and President of the Board of Trustees,*

*Annapolis, Maryland.*

SIR: In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2d, 1887, "To Establish Agricultural Experiment Stations," etc., I have the honor to transmit the Fourteenth Annual Report of the Maryland Experiment Station for the fiscal year ending June 30th, 1901.

Very respectfully yours,

H. J. PATTERSON,

Director of the Expt. Station.

July 15, 1901.

# THE MARYLAND
# AGRICULTURAL EXPERIMENT STATION.

VOLUME 14. 1900-1901.

## THE
## FOURTEENTH ANNUAL REPORT.

For the Fiscal Year, July 1, 1900, to June 30, 1901.

By the Director.

In submitting the report for the past fiscal year it might not be out of place to preface it with a brief historical sketch of the work of this experiment station up to the present time, and thus supply the frequent demands for this information.

*Historical Sketch*—In this connection it may be of interest to some to know that the first act of a state legislature providing expressly for experimental work in agriculture in America was embodied in Section 6 of the act to establish and endow an agricultural college, passed by the legislature of Maryland in 1856 and which reads as follows:

"It shall be the duty of the said board of trustees to order and direct to be made and instituted on said model farm, annually, a series of experiments upon the cultivation of cereals and other plants adapted to the latitude and climate of the state of Maryland, and cause to be carefully noticed upon the records of said institution the character of said experiments, the kind of soil upon which they were undertaken, the system of cultivation adopted. the state of the atmosphere, and all other particulars which may be necessary to a fair and complete understanding of the result of said experiments."

The records of the college show that in 1858, immediately after the college was located, and before building began, field experiments with corn, oats and potatoes, "to test the relative values of different manures offered for sale in the cities of Baltimere and Washington," were commenced on the college farm. This work continued for two or three years, but was interrupted by the financial distress which soon affected the whole country and by the disturbed political condition of the state and nation. The records give no evidence of any attempt at systematic experimentation from the time of this interruption until the establishment of the present department as provided for by the Congressional Hatch Act of March 2, 1887. This act appropriated $15,000 annually to each state for research work in agriculture and kindred subjects. The Hatch Act did not directly carry an appropriation, so it did not become operative until provided for by the 50th Congress by an appropriation act approved February 2, 1888. The terms of the Hatch Act were formally assented to and accepted by an act of the Maryland Legislature, approved March 6, 1888, whereby the Maryland Agriculture College was made the beneficiary of this fund. The experiment station, by this act became a department of the college, which connection works to the mutual advantage of both institutions. From

1888 to 1892 the president of the college was also director of the experiment station, but in 1892 the board of trustees so far separated the station from the college as to put it under a special director, who has no college duties or connection and who is directly responsible to the Board.

*Organization:*—The College is a combined State and stockholder institution, and, with its experiment station, is governed by a board of seventeen trustees, which consists of the Governor of the State, the President of the Senate, the Speaker of the House of Delegates, the Attorney General, State Treasurer and Comptroller, ex-officio; six members appointed by the Governor of the State, one practical farmer from each congressional district for a term of six years; and five members elected by the stock-holders and serving for one year or until their successors are elected. The Governor of the State is, ex-officio president of the board. This entire board of trustees elect the station officers and fix salaries,but all the expenditures are directed by a Station Committee consisting of five members of the board appointed by the Governor for a term of one year.

*Equipment:*—At the present time all the college property, except that occupied by the college buildings and campus, is under the control of the Experiment Station. This provides about 200 acres under cultivation and 60 or 70 acres in woodland, which is available as a run for cattle in connection with the permanent pasture. About 50 acres are devoted to plot experiments and most of the general farm to rotation experiments.

The buildings of the Station are as follows:

1. The main building which contains the director's office, general office and mailing room, clerk's office, library, chemical laboratory, and dairy bacteriology laboratory, and quarters for some of the force. 2. The horticultural building, which contains the offices of the horticulturist, agriculturist and farm superintendent. 3. Green houses and propagation houses. 4. Creamery. 5. Main barn. 6. Feeding experiment barn. 7. Piggery. 8. Tool shed, corn crib and sheep shed. 9. Large round barn, cantaining two 60-ton silos. 10. A round silo 120-ton capacity. 11. Wagon shed,corn crib and granary (near the round barn). 12. Air-curing tobacco barn. 13. Flue curing tobacco barn. 14. Garden-tool house. 15. Besides the accommodations given by the above named buildings, the laboratories of the entomologist, vegetable pathologist and veterinarian are located in the Morrill Science Hall.

In some cases the equipment of the different divisions is fairly good but in others it is rather meager. In all departments the aim will be to place the best facilities for work which can be devised at the command of the workers as rapidly as the funds of the Station will permit.

*Lines of Work:*—The work of the Agricultural Experiment Station is defined by the second section of the Hatch Act, which is as follows:

"That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments in the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and waters; the chemical composition of manures natural or artificial, with experiments designed to test their comparative effects on crops of

different kinds; the adapation and value of grasses and forage plants; the composition and digestibility of the different foods for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States, as may in each case be deemed advisable, having, due regard to the varying conditions and needs of the respective States or Territories."

The station has no control or police duties but has confined itself quite strictly to investigation. The work of the station, in the early days of its existence, was confined largely to subjects relating to fertilizers, rotation culture and variety, both with agricultural and horticultural crops; feeding experiments with cows, steers and swine, and studies of laboratory method. These lines have been continued and additions made and the work broadened whenever the means at hand would permit and the opportunity was presented. The policy has been to build on a good solid foundation and to have all the station workers put forth their best efforts in solving problems that will have a value for future as well as for immediate application.

Owing to the great diversity of agricultural conditions in this state there is an innumerable number of questions which might be made the subject of experimentation, but with the relatively small amount of money, at our command, we must of necessity, limit the lines of work which we engage in, and concentrate all our efforts upon a few subjects in each line, rather than attempt to cover all interests and meet all demands. For information other than that obtained from our own investigation we must depend upon results obtained elsewhere.

This is the policy which has been aimed at in the past, and, I believe, that our future success demands that it be made still more pronounced; so that, rather than attempt to broaden our work by adding new departments of research, I believe we should expand those already established and put them on the broadest possible footing.

*List of Experiments in Progress.*—The principal lines of work now in progress are as follows:

The chemical division has under its charge a number of lines of investigation which have been in progress for several years, and which should be continued for a considerable time, in order that errors may be eliminated and that the conclusions drawn may be verified and warranted. The principal ones of this class are the special fertilizer tests with phosphoric acid, potash, nitrogen and lime. In addition to these the chemical division has in progress feeding experiments with cows, calves, and hogs; curing experiments with tobacco, and tests of methods and general laboratory work.

The chemical division has some experiments in progress in conjunction with the dairy division. The principal one, which is now about completed, is a study of the digestibility of raw, Pasteurized and sterilized milk; also a study of the effect of milk-preservatives upon its digestibility. These studies have occupied a large part of the time of both chemical and dairy divisions.

The dairy division also has in hand a long series of experiments and investigations upon the conditions which affect the keeping qualities of milk, which involve considerable bacteriological work; and some investigations upon the causes which affect the amount of water in finished butter with an idea, if possible, to formulate some plan which would maintain the amount of moisture within reasonable limits.

The agricultural division has in progress the following experiments, besides taking part in some of the co-operative work hereafter outlined:

1. Agricultural grasses and legumes; comparison of thirty-two varieties, as to their adaptation to local, climatic and soil conditions, productiveness, longevity, aggressiveness, time of development and special usefulness for hay or pasture. Begun in fall of 1899.

2. Experiment to determine the best method of using stable manure as to time and manner of application—twenty plots. Begun in fall of 1899. Duplicate experiments begun in summer of 1900.

3. Experiment to determine the best method of cultivating corn. Begun in spring of 1900.

4. Experiment to determine the best time for planting field corn. Begun in spring of 1900.

5. Experiment to determine the comparative value of thick, medium-thick and thin planting of corn.

6. Experiment to determine the best method of applying commercial fertilizers to corn in connection with stable manure.

7. Experiment to determine the effect of different methods of planting, cultivating and manuring corn upon the stand and development of crimson clover following corn. This experiment follows experiments 2 to 6 inclusive.

8. Experiment to determine the relative value of first and second crop seed potatoes. Begun in 1900; continued in 1901.

9. Experiment to determine the best method of cultivating potatoes. Begun in 1900; continued in 1901.

10. Experiment to determine the practicability of growing cowpeas, with corn. Begun in 1900; continued in 1901.

11. Experiment to determine the effect of early and late turning under of crimson clover as preparation for late potatoes. Begun in fall of 1900.

12. Experiment to determine the hardiness of fall-seeded alfalfa. Begun in fall of 1900.

13. Experiment in inoculating soil for soy beans. Begun in fall of 1900.

14. Experiment in improvement of wheat by selection of seed. Begun in 1898.

The horticultural division has in progress considerable work both in

green house and in open ground culture, the principal of which are as follows:

1. A study of the most desirable green-house rotations.

2. A study of chemical manures for green-house crops, (both vegetables and flowers.)

3. An investigation upon the preparation of green-house soils and substitutes for composted old sods.

4. Plant improvement by selection and breeding with fruits, vegetables and flowers.

5. Investigations of markets and points allied thereto, for Maryland fruits and vegetables.

6. Testing of Persian and North China types of peaches as to their adaptability to Maryland for orchard culture. (These fruits for the first time this season, 1901).

7. Experiments upon thinning fruit, as to the profit from the immediate crop and its effect upon the development of fruit-buds for the succeeding cropr.

8. Variety tests with strawberries, tomatoes, melons and sweet potatoes. The work on melons and sweet potatoes is in co-operation with the United States Department of Agriculture.

The division of Plant Pathology has special investigations in progress upon the following topics:

1. Peach yellows.

2. Trunk blight of pear and apple.

3. Twig blight of pear and apple.

4. Apple rot.

5. Bark diseases of young apple trees.

6. Asparagus rust.

7. Cantaloupe blight.

8. Diseases of carnations.

The division of Entomology has extensive studies in progress on methods of treating San Jose scale, particularly in the use of crude petroleum under the conditions existing in Maryland. Also the methods for combating the pea louse are being carefully studied.

The divisions of Plant Pathology and Entomology are mostly occupied with the inspection work connected with the State Horticultural Inspection Law; yet must do considerable investigation in order to determine the best mode of procedure in carrying out the provisions of the law. After doing this work there is not much time left for these divisions to take up outside investigations.

The veterinary division is attached to the Station more in the capacity for consultation than for research work; yet, when the opportunity is presented, and the means of the Station will permit, some investigations

are conducted when the questions involved are either of a local nature or are of special interest to this State, and are not being made the subject of investigation by the United States Department of Agriculture. At the present time the following subjects are under consideration by the veterinarian:

1. Acute Haemorrhagic Eucephalitis of Horses. This disease has been positively identified within the past few months, and is *Not*, as commonly supposed, "Cerebro-Spinal Meningitis" or "Staggers." With the recent light on this disease there is now some hope of solving the problems connected therewith and determining remedial measures. The Pathological Department of Johns Hopkins University is co-operating in the study of this disease. A joint preliminary report of the disease has been published in May number of the American Veterinary Review.

2. Mammitis or Garget has been made the subject of investigation owing to its general importance and to the fact that it commonly results as a complication of Parturient Paresis.

3. Parturient Paresis or Milk Fever of cattle is found quite commonly in the dairy herds of the State and the veterinarian has been called upon to treat a number of cases. Considering the importance to dairymen of knowledge of this disease it has been made the subject of observation, particularly the results obtained by following the method of treatment recommended by Schmidt of Denmark. The experience so far has been that Schmidt's treatment is highly satisfactory. This has been treated in Bulletin No. 76.

*Cooperative Experiments:*—The United States Department of Agriculture has, from time to time. ever since the establishment of the experiment station, cooperated with the Station in conducting some experiments. Such cooperation has been mutually beneficial and productive of much good, but has had the objection in the past that it was rather spasmodic in its nature and lacked that fixedness in character and policy that is desirable in all such work. Happily for all interested, the future gives promise of much good from cooperation with the U. S. Department of Agriculture, as this class of work has received explicit recognition by the 56th Congress, as the appropriation act for the U. S. Agrl Dept. for the coming fiscal year makes frequent mention of cooperation between the different divisions of the Department and the agricultural experiment stations.

The general plan adopted in cooperative work is for each side to contribute that help which they are respectively best able to supply and make an equitable adjustment of expenses accordingly. This not only gives opportunity for the U. S. Department to carry on lines of work, which, under old conditions, were impossible, but it also enables the Station to conduct work and give farmers reliable results and help, which otherwise would be impossible with the Station's limited income. The results obtained from the cooperative experiments are for the free use of both institutions, but the general understanding exists that this Station shall have preference in those matters of direct interest to Maryland, and that the U. S. Department of Agrl. shall have preference in those matters that are of interset in connection with similar lines of work in other parts of the country.

This Station has in progress at the present time cooperative experiments upon the following subjects.

1. Cooperative investigations upon cereals, which embrace the improvement of the quality of wheat, barley and other grains. Producing varieties better adapted to the region and otherwise making them more valuable, particularly as regards the time of maturing, yielding power, disease resisting and quality of the grain.

2. Cooperative grass and forage plant investigations; which has particularly in hand the working out of a scheme of soiling crops which will not only give an abundance of green roughage for as great a portion of the year as possible, but also for determining the best means of always having available a combination of leguminous and graminaceous crops.

3. Cooperative investigations upon the influence of the origin of clover seed on the yield of the crop.

4. Cooperation with the Division of Chemistry in testing the effects of locality upon the quality of wheat.

5. Cooperative experiments on variety and culture tests of sweet potatoes.

6. Cooperative tests of different varieties of foreign apples and peaches.

7. Cooperation with the Division of Soils.

8. Cooperative tests upon foreign varieties of melons.

Besides the cooperative work with the U. S. Dept. of Agrl., the Station has in progress numerous cooperative experiments with farmers of the State, the principal ones of which are as follows:

1. Tests at several points in every county of the State in growing alfalfa.

2. Work in the improvement of corn, as to quantity and quality, by selection.

3. Culture tests with corn.

4. Tests in spraying for control of insect pests.

5. Tests in spraying fruits and vegetables for the control of plant diseases.

6. Tests of varieties of fruits in different sections.

*General Results of Experiment Station Work:*—The Maryland Station has done much useful work in the promotion of the diversification of agriculture in the State, and the development of more intensive and modern methods of farming. The horticultural interests of the state have been promoted especially by pointing out of improved methods of handling and marketing of fruits and vegetables and by illustrating the opportunities offered by different markets and the varieties adapted to the same. The introduction of scientific methods for the repression of insect pests and plant diseases has been of inestimable value to the horticultural interests.

Farmers have been shown the desirability of a discriminating use of fertilizers and the advantages of more careful culture of their crops.

The establishment of dairy farming and dairying on a modern scientific basis has been helped by the feeding experiments and other work conducted by the Station.

The soil studies have been especially important as laying a solid foundation for the rational development of agriculture. The work of the Maryland Station on soils led to the establishment of the Bureau of Soils of the U. S. Department of Agriculture, and almost all of their present work had its inception, in all essential details, in the investigations conducted here. The Soil Survey, with the methods of classifying lands and the detailed mapping of soils, was first worked out and put in practice by this Station. These Soil Surveys, and the soil maps derived therefrom, with the accompanying agricultural review, will be of great help and value in locating lands for specific classes of farming and will do much toward settling up sections of the country, and in bringing lands under cultivation that are now unoccupied.

*Dissemination of Information:*—The Station endeavors to bring the results of its work promptly before the people of the State in every way possible. The means which are used are: 1. Bulletins; 2. Correspondence; 3. Station Officers giving lectures and talks before farmers' institutes, clubs and granges and other meetings of an agricultural nature; 4. By showing and explaining the work to visitors; 5. By making exhibits at county fairs.

So far the Station has published 74 regular bulletins, 11 special bulletins lettered from A to K (the issuing of this Lettered Series has been discontinued), and 13 annual reports. The special bulletins were confined mainly to reports of analyses of commercial fertilizers by the State Control, but, since 1898 this matter has been published in the Agricultural College Quarterly. The first four annual reports contained the results of many experiments not published in any other way. Annual reports 5 to 11 contained only matter of an administrative character. The annual report at present, beginning with No. 12, is issued in a limited edition, and consists of an administrative document, to which is appended the bulletins published during the year.

The regular bulletins are issued to the regular mailing list, which contains 10,000 names. There are also special mailing lists covering the following subjects: Creameries and creamery patrons, Milk Shippers, Home dairy interests, Tobacco growers, Fruit growers, Truck farmers, Florists, Nurserymen, and general horticultural interests. These mailing lists are kept for reference by the card-index system, but printed for mailing with a Dick Mailer. It is regretted that a larger percentage of the farmers of the State do not have interest enough in agricultural advancement to have their names placed on the regular mailing list. We should be glad to reach each of the 40,000 farms of the State, but this is more than can reasonably be expected; yet there should be at least one interested farmer receiving mail at every postoffice in the State, but there are postoffices to which we send no bulletins.

| Publication. | Title. | Author. |
|---|---|---|
| 1888 | | |
| Bulletin 1 | History, Organization and work of the Station, | H. E. Alvord. |
| " 2 | Cutting Seed Potatoes for Planting, | Do. |
| " 3 | Fodder Corn and Fodder Cane, | Do |
| Annual Report | First Annual Report, 1888, | |
| 1889 | | |
| Bulletin 4 | Experiment Orchards, | W. H. Bishop. |
| " 5 | Horticultural Department and Field Experiments, | H. E. Alvord. |
| " 6 | Commercial Fertilizers, | H. E. Alvord and H. J. Patterson. |
| " 7 | Farm Manures, | H. E. Alvord. |
| Spec. Bul. A. | Facts About the Station, | Do. |
| Annual Report | Second Annual Report, 1889, | |
| 1890 | | |
| Bulletin 8 | Some Feeding Trials, | A. I. Hayward. |
| " 9 | Strawberries, Variety, Comparisons etc. 1890 | W. H. Bishop. |
| " 10 | Wheat, Effects of Different Fertilizers, | A. I. Hayward. |
| " 11 | Tomatoes in 1890, | W. H. Bishop and H. J. Patterson. |
| Spec. Bul. B. | Potash and Paying Crops, | H. E. Alvord and J. D. Hird. |
| Spec. Bul. C. | Composition of Commercial Fertilizers Sold in the State | H. E. Alvord. |
| Annual Report | Third Annual Report 1890, | |
| 1891. | | |
| Bulletin 12 | Pig Feeding, | H. E. Alvord and A. I. Hayward. |
| " 13 | Strawberries. Season of 1891, | J. S. Robinson. |
| " 14 | Wheat Season of 1891, | A. I. Hayward. |
| " 15 | The Experiment Vineyard, | T. L. Brunk. |
| Spec. Bul. D. | Composition of Commercial Fertilizers Sold in the State, | H. E. Alvord. |
| Spec. Bul. E. | Composition of Commercial Fertilizers Sold in the State, | Do. |
| Annual Report | Fourth Annual Report, 1891, | |
| 1892. | | |
| Bulletin 16 | Wheat Insects, | E. W. Doran. |
| " 17 | Strawberries and Seed Potatoes, | J. S. Robinson. |
| " 18 | Sweet Potatoes, | E. H. Brinkley. |
| " 19 | Tomatoes, | J. S. Robinson. |
| Spec. Bul. F. | Agricultural Outlook for Maryland, | E. Stake. |
| Spec. Bul. G. | Commercial Fertilizers, | H. E. Alvord. |
| Spec. Bul. H. | Government Direction of Agriculture in Europe | J. E. Ray, Jr. |
| Spec. Bul. I. | Commercial Fertilizers, | |
| Annual Report | Fifth Annual Report, 1892, | |
| 1893. | | |
| Bulletin 20. | The Composition and Digestibility of different parts of Corn Fodder, | H. J. Patterson. |
| " 21 | Soils of Maryland, | M. Whitney. |
| " 22 | Steer Feeding, Well Balanced vs Poorly Balanced Ration, | R H. Miller. |
| " 23 | Injurious Insects of Maryland, | C. V. Riley. |
| Spec.Buls. J.K. | Commercial Fertilizers, | H. B. McDonnell. |
| Annual Report | Sixth Annual Report, | |

| Publication. | Title. | Author. |
|---|---|---|
| 1894. | | |
| Bulletin 24 | Composition of Commercial Fertilizers Sold in the State, | H. B. McDonnell. |
| " 25 | Corn, Potatoes, Tomatoes, Strawberries, Grapes etc, | R. H. Miller and E. H. Brinkley. |
| " 26 | Tobacco, | H. J. Patterson. |
| " 27 | Composition of Commercial Fertilizers Sold in the State, | H.B.McDonnell et al. |
| " 28 | Experiments with Wheat and Barley, | R. H. Miller and E. H. Brinkley. |
| " 29 | Further Investigations on the Soils of Maryland. | M. Whitney and S Key. |
| Annual Report | Seventh Annual Report 1894, | |
| 1895 | | |
| Bulletin 30 | Composition of Commercial Fertilizers Sold in the State; The Fertilizer Law; Appendix; Table for Calculating. Fertilizer Analyses and Valuations. | H.B.McDonnell et al. |
| " 31 | Potato Experiments, | R. H. Miller and E. H. Brinkley. |
| " 32 | San Jose Scale, | C. V. Riley. |
| " 33 | Small Fruits, Vegetables and Field Corn,. | J. S. Robinson. |
| " 34 | Composition of Commercial Fertilizers Sold in the State, | H.B.McDonnell et al. |
| " 35 | Wheat, Barley, Oats and Hay Experiments, | R. H. Miller and E. H. Brinkley. |
| " 36 | Steer Feeding, A well Balanced vs. A Poorly Balanced Ration, | Do. |
| Annual Report | Eighth Annual Report, 1895, | |
| 1896 | | |
| Bulletin 37 | Composition of Commercial Fertilizers Sold in the State, | H.B.McDonnell et al. |
| " 38 | Potato Experiments, | R. H. Miller and E. H. Brinkley. |
| Bulletin 39 | Spray Calendar | R. H. Miller. |
| " 40 | Composition of Commercial Fertilizers sold in the State. | H.B.McDonnell et al. |
| " 41 | Test of Methods of preparing and Feeding Corn Fodder, | H. J. Patterson. |
| " 42 | The Maryland Trees and Nursery Stock Law, and other information of special interest to fruit growers, | W. G. Johnson. |
| " 43 | Report upon the Value of the New Corn Product, | H. J. Patterson. |
| " 44 | The Soils of the Hagerstown Valley, | C. W. Dorsey. |
| Annual Report | Ninth Annual Report 1896, | |
| 1897 | | |
| Bulletin 45 | Composition of Commercial Fertilizers Sold in the State, | H.B.McDonnell et al. |
| " 46 | Corn and Potato Experiments, | R. H. Miller and E. H. Brinkley. |
| " 47 | Dairy Farming, | H. J. Patterson. |
| " 48 | Some Common Injurious Plant Lice, with Suggestions for their Destruction, | W. G. Johnson. |

| Publication. | Title. | Author. |
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| " 49 | Composition of Commercial Fertilizers Sold in the State, ........................ | H.B.McDonnell et al. |
| " 50 | Rust and Leopard Spot; Two Dangerous diseases of Asparagus,............ | W. G. Johnson. |
| " 51 | Horse Feeding; Test of Digestibility of Oats, Corn, Hay and the New Corn Product, .......................................... | H J. Patterson. |
| Annual Report 1898 | Tenth Annual Report, 1897,................ | |
| Bulletin 52 | Composition of Commercial Fertilizers Sold in the State,...................... ..... | H.B.McDonnell et al. |
| " 53 | Special Investigation of the So called "New" Horse Disease in Maryland, | S. S. Buckley. |
| " 54 | Tomatoes.......................................... | J. S. Robinson. |
| " 55 | The Black Peach Aphis; Cut worms in Young Tobacco; Law Providing for the Suppression and Control of Insect Pests and Plant Diseases in Maryland,........................................ | W. G. Johnson. |
| " 56 | Wheat, Winter Oats, Barley and Lime Experiments,....................... ........ | R. H. Miller and E. H. Brinkley. |
| " 57 | Report on the San Jose Scale in Maryland Remedies for its Suppression and Control,.................................... | Do. |
| " 58 | The Hessian Fly,...................... ........... | C. O. Townsend. |
| Annual Report 1899 | Eleventh Annual Report, 1898,............ | |
| Bulletin 59 | Sweet Potato Insects,...... .................... | E. D. Sanderson. |
| " 60 | Some diseases of the Sweet Potato and How to Treat them,........................ | C. O. Townsend. |
| " 61 | The Sugar Beet in Maryland,................ | H. W. Wiley. |
| " 62 | Experiments with Wheat, Corn and Potatoes, ......... ......................... | H. J. Patterson et al. |
| Annual Report 1900 | Twelth Annual Report, 1899,............. . | |
| Bulletin 63 | Experiments with Feeding Pigs,......... | H. J. Patterson. |
| " 64 | A Study of the Cause of Mottled Butter, | C. F. Doane. |
| " 65 | Insecticides, Fungicides and Spraying Apparatus,.......................................... | W. G. Johnson, C. O Townsend and H. P. Gould. |
| " 66 | Lime, Sources and Relation to Agriculture............................................. | H. J. Patterson. |
| " 67 | The Culture and Handling of Tobacco, | Do. |
| Annual Report 1901 | The Thirteenth Annual Report, 1900.... | |
| Bulletin 68 | Fertilizer Experiments with Different Sources of Phosphoric Acid,.......... | H. J. Patterson. |
| " 69 | The Influence of Feed and Care on the Individuality of Cows,.................. | C. F. Doane. |
| " 70 | The Chemical Composition of Maryland Soils, ............................................. | F. P. Veitch. |
| " 71 | Notes on Spraying Peaches and Plums in 1900,........................................ | C. O. Townsend and H. P. Gould. |
| " 72 | Peach Growing in Maryland,... .......... | H. P. Gould. |
| " 73 | Suggestions About Combating the San Jose Scale,.................................. | H. P. Gould. |

| Publication. | Title. | Author. |
|---|---|---|
| Bulletin 74 | Notes on the Diseases of Celery, .......... | C. O. Townsend. |
| " 75 | Hydrocyanic-acid Gas Effect upon Grains and other Seeds,. ............... | C. O. Townsend. |
| " 76 | Parturient Paresis—Milk Fever, Calving Fever.................................... | Samuel S. Buckley. |

*Station Staff:*—This Station has, from the beginning, suffered more or less from time to time by changes in the personnel of its force and by the interruptions to work and variations in plans which were incurred thereby. While such conditions have not been more prevalent at this ininstitution than at most of those of the United States, yet they have been more frequent than is desirable in the future. One of the troubles that confront us is that similar institutions in other states, and the U. S. Department, pay higher salaries than are paid here. At the present time, with the great expansion going on in the U. S. Department of Agriculture and in several of the State Experiment Stations, there are numerous opportunities being presented for good men to change, and thereby not only better their pay but also their facilities for work. Located as this institution is, under the shadow of the U. S. Department, it makes us more subject to the above named condition than the states further removed. Hence in order to meet these conditions and have as few changes and interruptions as possible, it will be necessary for this institution to put its salaries at least on a par with similar positions in the U. S. Department of Agriculture, for, although located in the country, living expenses are the same as in the city and generally accompanied by much more inconvenience. Also it will be necessary, as fast as possible, to provide better facilities for work. Again, much could be accomplished in holding men and getting better service from them by making their positions more secure and permanent by abandoning the system of annual elections. To accomplish both of these suggestions means that the policy previously mentioned will be carried out, of limiting the lines of work and getting the best experience and talent and facilities for conducting the same.

The relation of the staff to each other and to the institution with which they are connected, has been so well summed up by Director True of the U. S. Office of Experiment Stations in his report upon the work of the Experiment Stations for 1900 that it will be well to quote therefrom as follows: "As regards the business of the Station, the director should be clothed with a large measure of authority and consequent responsibility, should plan and supervise its work and expenditures, and control its staff to such an extent as will bring them together to work as a unit for the promotion of the station's success. The members of the staff should be directly responsible to the director on all matters relating to the station, whatever their position may be in other departments of the college, and should expect to transact station business through the director rather than through the college president or the governing board. A proper inde-

pendence in the conduct of investigations, or parts of investigations, in their respective specialties and just credit for their share in the station's operations as set forth in publications or otherwise, may, it is believed, be amply secured for the expert officers of the stations at the same time that good discipline is maintained and ample provision made for united effort.

No class of men need to readjust their professional code to the modern requirements of the organization of great scientific and educational enterprises more than college professors and scientific specialists. A way must be found by which teaching and research can be conducted on a system which combines liberty with law. The old régime of the entirely independent teacher and investigator has passed away. The specialization, which is simply a form of the division of labor, well known in industrial pursuits, carries with it a necessity for combination of workers in educational and scientific institutions, as well as in manufacturing establishments. In a way hitherto unknown scientific men will be called in the future to work together for common ends. No matter is of more vital importance to the organization of our colleges and experiment stations than the securing of harmonious and concerted action on the part of faculties and staffs for the common good of the institution to which they are attached. One of the greatest difficulties now attending the successful management of these institutions is the fact that, while specialiization has narrowed the field and out-look of the individual officer, there has been a corresponding recognition of the necessity of readjusting the form of organization and the spirit of the worker to meet these new conditions. At no time has there been a greater need for the cultivation of an earnest and enthusiastic *esprit du corps* among the rank and file of educational and scientific workers. There are many individual examples of men impressed with this lofty sentiment, but the whole body is not yet animated with it. Obviously it should especially be a virtue characteristic of men connected with public institutions. The officers of our agricultural colleges and experiment stations are public functionaries employed to advance very important public interests. With them the good of the community, as involved in the success of the enterprise with which they are connected, should be the ruling motive of action. The fame and emoluments of the individual worker should be subordinated to the requirements of concerted action for a common end. And yet, in the long run it is believed, the individual worker, as well as the institution, will profit by a loyal and self-sacrificing discharge of common duties, for union of effort will bring greater success; and, whenever a college or station is strong or flourishing, credit is reflected on every worker who has contributed to this issue."

"It continues to be a weakness of a considerable number of stations that they are organized on too broad a scale for their resources. Too great a portion of their funds is going into salaries, leaving too little to pay the miscellaneous expenses of important investigations. Here and there only have the authorities had the wisdom and courage to confine the operations of the station within comparatively narrow lines, leaving important departments of work entirely without recognition.

"The general considerations affecting the efficient organization of our experiment stations have thus been dwelt upon because a survey of these institutions during the past year has brought additional evidence that the problems of organization are being more generally considered than ever before. The tide is running strongly toward a more compact organization and a greater unification of the work. On the whole those stations which have a strong organization and administration are meeting with the largest measure of success."

This whole matter may be summarized by considering that the agricultural experiment station is nothing more or less than a business institution for conducting investigations in agriculture, and that every person and thing is simply an integral part of the machinery for accomplishing that end; and, on such a basis, everything should be conducted as nearly as possible, on such business principles as would pervade a private institution.

With the close of this fiscal year the personnel of the Station staff has changed as follows:

In August, 1900, G. L. Steward resigned as assistant plant pathologist to accept a position with the Industrial Division of the B. & O. R. R. This vacancy was filled by the appointment of R. H. Pond, M. S., of Kansas Agricultural College and Michigan University. R. H. Pond resigned in June, 1901 to accept a position with the U. S. Fish Commission, this vacancy has been provided for by the appointment of H. C. Whiteford, graduate of the Maryland Agricultural College, class of 1901.

W. G. Johnson resigned as Entomologist, February 1st, 1901, to accept a position on the editorial staff of the American Agriculturist. The work of this department was carried for the balance of the fiscal year by H. P. Gould. The vacancy was filled at the June (annual) meeting of the board of trustees by the appointment of A. L. Quaintance M. S., of the Georgia Experiment Station and the position to be designated as Entomologist and Associate Horticulturist.

H. P. Gould resigned July 1st, the position of Assistant in Entomology and Horticulture to accept a position in the Pomological Division of the U. S. Department of Agriculture. This vacancy has been provided for by the appointment of E. P. Sandsten, M. S., a graduate of the Minnesota Agricultural College and Minnesota University and post graduate of Cornell University. The position to be designated as General Horticultural Assistant, State and Station work.

C. O. Townsend resigned as plant pathologist to take effect July 1st, to accept a position in the Division of Vegetable Pathology, U. S. Department of Agriculture. This vacancy has been provided for by the appointment of

F. P. Veitch resigned his position on the soil work to accept the position as assistant soil chemist in the Bureau of Soils, U. S. Department of Agriculture. Considering this change and the small amount of money available for this work, Prof. Whitney has recommended that the Station discontinue its regular soil work and that the same be absorbed entirely by the Bureau of Soils of the U. S. Department of Agriculture. This

recommendation has been accepted with the understanding and promise of Prof. Whitney that the interests of Maryland should not suffer and that all class of the soil work for this State will be pushed forward as rapidly as though the Station kept an assistant in this division.

Donald Eversfield resigned as clerk to accept a position in the U. S. Land Office. This vacancy was provided for by the appointment of B. H. Gibbs, a graduate of the Washington Business High School.

## APPRENTICESHIPS IN AGRICULTURE.

The Agricultural Experiment Station, instead of having all the work in the dairy and horticultural divisions performed by regular paid laborers; has some performed by apprentices. The apprenticeships in these divisions have been established with five objects in view, viz:

1st. In order to offer to young men, who have a good common school education and who have not the means for taking either a regular college course or even a short course, an opportunity to become trained and skilled laborers in the dairy or some class of horticultural work.

2nd. In order to enable young farmers to take up and engage in some of the specialties in farming on their own farms in an intelligent manner.

3d. In order to supply some of the numerous applications that come to the College and Station for skilled help of the character indicated.

4th. In order to give the College and Station a nucleus for the extension of their work and a more appreciative constituency.

5th. In order to have some of our labor performed by persons who have more interest in what they are doing than the money they are to receive.

These apprenticeships are open to farmers' sons on the following terms: The Station will board and room the apprentice or pay the equivalent in money, as preferred.

The Station will furnish the instruction and facilities for instruction given in the several branches pertaining to the specialty taken up.

Those serving a dairy apprenticeship will be expected to devote from three to five hours of each day in receiving class room instruction and in study besides the time devoted to practice in the skilled operations. It is expected that apprentices shall be thoroughly familiar with the scientific feeding of dairy stock and with all the modern practices pertaining to dairy and creamery management. The plan pursned is to divide the work which would ordinarily be performed by one laborer among three apprentices. A dairy apprentice is expected to stay at the Station for six months.

The horticultural apprentices are to serve for one year on the same terms as the dairy apprentices. The instruction taken in this division will be given at the same time and with short course students of the College. The horticultural apprentice will be expected to take part in all classes of work of this division, bnt he may specialize so as to become specially skilled in either large fruits, small fruits, truck crops, floricul-

ture, nursery management, green house management, or spraying. The apprentices shall have access to the libraries and reading rooms of the Station at all times.

The Station can accommodate but a limited number of apprentices and vacancies will be filled in the order in which applications for the same are received.

After an apprentice has served his time and should he desire a position we will take pleasure in recommending him to a place whenever we have a request for skilled help in that particular line; provided that such apprentice has proven himself worthy. So far we have had more applications for skilled help on farms and in creameries than we have been able to supply.

Make applications and requests for further information to

The Director of the Md. Agrl. Ex. Station,
College Park, Md.

*Suggestions and Recommendations.*—The Station has many needs, some of which can be gradually met out of the annual appropriation which it now receives, but it has many more which it can never realize unless the importance of the work in hand is appreciated and provided for by the State Legislature.

In this connection it may not be out of place to remind the people of the State that this institution, (The Maryland Agricultural Experiment Station) has been conducted for the past thirteen years without one dollar of expense to the State of Maryland.

In general it may be said that an institution of this nature located in connection with the Agricultural College where the youth of the State is being educated, particularly in modern and scientific agriculture, should possess the most modern and improved farm buildings and farm appliances. These should be provided for wholly by the State so as to not encroach upon the funds appropriated by the national government, which was intended to be used strictly for research.

This institution should be provided with the most approved types of green-houses, equipped with the most modern appliances. The dairy barns, creamery, poultry plant, &c. should be models of their kind. Such buildings need not, and really should not be, extravagant in their architecture or appointments, yet they should be of such a character as to serve as models of their type. If the growers of vegetables under glass, the florist, the dairyman, the stock-raiser, or the poultryman wants to see a modern and model plant for his business, he ought to find it at the Agricultural College and Experiment Station. These institutions should be able to say that we have got the best and most modern farm buildings and appliances in the State, and that they will serve as models for those interested in such matters. We should not have to send our constituents, and even our students, to private properties to find models for such plants. If Maryland is to keep in the procession in agricultural education and experimentation these model equipments should be provided.

It was the expectation of Congress, when the Hatch bill was passed, that the states would at least furnish the home, and such equipment as could be classed as permanent, for the Experiment Station, and that the Hatch fund would be used almost wholly for research. This being the case, and with the amount of buildings the Station has now acquired, it is almost impossible to care for them as should be without encroaching upon the proper use of the Hatch fund. Therefore it would seem to be wise for the State to make provision for the maintenance, repair and insurance upon the Station buildings.

It would also be well to have an appropriation to put grounds and roads in good order in a permanent shape, and a small allowance for their annual maintenance. Again the Station could do much good by bringing its work before the people in the shape of exhibits at fairs and farmers' Conventions, and posting placards at public places. This class of work is exceedingly expensive and the Station has no funds to take up the work on a proper scale, as the U. S. Government has made a ruling against the use of the Hatch fund in this way.

There are also some lines of experimentation which could be profitably engaged in if funds were sufficient for the purpose. One such line merits particular attention at this time and should receive substantial recognition at the hands of the State as the industry is directly allied to the revenues of the State and the prosperity of one section of the State seems so intimately connected therewith. That is the tobacco crop and investigations for its improvement. There is no doubt but that the tobacco sections of the State would be better off if the people did not rely upon this one crop so completely, and that they would have greater prosperity and the lands would improve and be kept in better condition of fertility if a mixed husbandry were practiced, particularly if stock-raising were more largely engaged in. While this fact is widely recognized, yet it is impossible to bring about the change at once as the people and conditions are not ready for it; and tobacco is bound to be the staple money product for a considerable time to come. This being the case there should be no time lost in endeavoring to elevate the tobacco industry at the same time pointing out the needs of stock-raising and the means of combining and bringing it about.

The Station has already devoted considerable time and money to experiments with the tobacco crop, but this has always been done at more or less disadvantage owing to the limited scale upon which some of the work was conducted and also due to being performed outside of the most typical tobacco areas.

If the tobacco growers of the State desire it, and will procure a liberal support from the State for the purpose, the Station would like to take up some investigations on the tobacco crop on a considerable scale and locate the same on some of the typical tobacco areas of the State. The tobacco industry of the State does not want to procure greater quantities by growing greater areas but it wants less area, greater yields and better quality. Experiments to reach that end can not be performed on tenth-acre plots with a few hundred dollars.

*Weather Report.*—The weather for the growing season of 1900 was extremely unfavorable to crops. The spring was cold, wet and late. This was followed by a very dry spell and then excessive wet again the first half of June. The balance of June, July and August and the first half of September, were noted for being abnormally hot and dry. This condition was unfavorable to all crops throughout the season and particularly so for corn. The preparation of the land for seeding the fall grains and grasses was much delayed, first by the dry weather, then by the wet. This made the season later than usual, and even then the preparation was not just such as was desired.

The summary is given in the following table:

## METEOROLOGICAL SUMMARY FOR 1900.

TEMPERATURES IN DEGREES.
(FAHRENHEIT.)

| MONTH. | PRECIPITATION | Temperatures—Mean. | | | | Extreme Maximum. | Extreme Minimum. |
|---|---|---|---|---|---|---|---|
| | | Daily Means | Maximum. | Minimum. | Daily Range. | Record and Date. | Record and Date. |
| January | 1.71 | 31.6 | 41.9 | 21.3 | 20.6 | 61, 23rd. | 6, 4th |
| February | 5.69 | 33.0 | 43.0 | 23.1 | 19.9 | 64, 8th | 4, 2nd. |
| March | 1.57 | 38.8 | 47.7 | 29.9 | 17.8 | 67, 23rd. | 6, 18th. |
| April | 1.82 | 47.8 | 59.4 | 36.2 | 23.2 | 72, 8th. | 27, 26th. |
| May | 3.39 | 63.8 | 77.3 | 50.3 | 27.0 | 93, 15th | 37, 6th. |
| June | 7.15 | 74.2 | 84.5 | 63.9 | 20.6 | 97, 29th. | 52, 5th. |
| July | 2.08 | 79.3 | 92.6 | 66.0 | 26.6 | 103, 18th. | 50, 2nd. |
| August | 2.09 | 79.7 | 91.8 | 67.6 | 24.2 | 103, 11th. | 55, 2nd. |
| September | 5.59 | 74.1 | 86.4 | 61.8 | 24.6 | 100, 11th | 39, 19th. |
| October | 1.62 | 61.1 | 72.1 | 50.1 | 22.0 | 90, 6th. | 29, 20th. |
| November | 2.42 | 48.2 | 58.4 | 38.0 | 20.4 | 78, 21st. | 23, 15th. |
| December | 2.40 | 34.9 | 45.3 | 24.5 | 20.8 | 62, 24th. | 9, 17th. |
| Yearly | 37.53 | 55.5 | 66.7 | 44.3 | 22.4 | 103, July 18th and August 11. | 4, Feb. 2nd. |

*Financial Support:*—The financial support of the Station is derived entirely from the United States Hatch fund and the small amount which comes from the sale of farm products. The State of Maryland has contributed nothing toward the support of the Experiment Station, and whatever of value the farmers of the State have received from the Station has come to them without any cost to themselves or to the State.

There are many lines of work which the Station has been unable to engage in at all, and some of the experiments undertaken have not been prosecuted with that vigor which their importance would warrant, simply from lack of funds. One notable instance of this kind is the tobacco investigations. The tobacco crop needs special attention on the part of the State and because of the pronounced importance which this crop bears to the whole of Southern Maryland. If the tobacco growers of this State are sufficiently interested in their industry and make the proper demands upon the State for aid, which they are warranted in doing, the tobacco investigations can be conducted on a scale that will give results which will be of inestimable value to the State, and do much toward bringing prosperity to a section that is now in a lamentable condition and seems destined to still further retrogression. It may be interesting to mention in this connection that 28 states supplement the Hatch appropriation, and that many of the states that do not make regular appropriations, have made liberal special appropriations for buildings, etc. In some states the bulletins and annual reports are provided for in the state printing contracts and done at state expense.

With the limited amount which is allowed from the Hatch fund for buildings, repairs and permanent improvements, it has now become an embarrassing problem to be able to keep the buildings now belonging to the Station, properly painted and otherwise repaired; in fact it cannot be properly done, and much of that which should be promptly looked after must, of necessity, be put off for lack of funds.

The Treasurer's Report for the fiscal year ending June 30th., 1901 is as follows:

**Maryland Agricultural Experiment Station in Account with the United States Appropriation.**

DR.

| | | | |
|---|---|---|---|
| 1901. June 30. | To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1901, as per Act of Congress Approved March 2, 1887. | $15,000.00 | $15,000.00 |

CR.

| | | | |
|---|---|---|---|
| 1901. June 30. | By Salaries | 7,533.44 | |
| | " Labor | 2,765.79 | |
| | " Publications | 1,461.37 | |
| | " Postage and Stationery | 134.84 | |
| | " Freight and Express | 284.18 | |
| | " Heat, Light and Water | 372.89 | |
| | " Chemical Supplies | 91.20 | |
| | " Seeds, Plants and Sundry Supplies | 468.46 | |
| | " Fertilizers | 79.09 | |
| | " Feeding Stuffs | 462.37 | |
| | " Library | 130.22 | |
| | " Furniture and Fixtures | 226.67 | |
| | " Scientific Apparatus | 68.70 | |
| | " Live stock | 245.00 | |
| | " Traveling Expenses | 247.46 | |
| | " Contingent Expenses | 10.00 | |
| | " Buildings and Repairs | 418.32 | |
| | | $15,000.00 | $15,000.00 |

The above is a true copy, Signed, JOS. R. OWENS,
Treasurer Md. Agrl. Expt. Station.

**Maryland Agricultnral Experiment Station in Account With the Station Farm.**

DR.

| | | | | |
|---|---|---|---|---|
| 1901. June 30. | To | Receipts from other sources than United States for the fiscal year ending June 30, 1901, viz: | | |
| | " | Cash Balance July 1, 1900 | $ 98.72 | |
| | " | Cash from Farm Sales | 4,440.08 | |
| | | | $ 4,538.80 | $ 4,538.80 |

CR.

| | | | | |
|---|---|---|---|---|
| 1901. June 30. | By | Labor | $ 1,379.41 | |
| | " | Seeds, Plants and Sundry Supplies | 244.81 | |
| | " | Fertilizers | 172.25 | |
| | " | Feeding Stuffs | 924.70 | |
| | " | Tools, Implements and Machinery | 381.78 | |
| | " | Live Stock | 587.95 | |
| | " | Traveling Expenses | 134.56 | |
| | " | Balance | 723.34 | |
| | | | $ 4,538.80 | $ 4,538.80 |

The above is a true copy, Signed, JOS. R. OWENS,
Treasurer Md. Agrl. Expt. Station.

THE MARYLAND

# AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 68. September, 1900.

## FERTILIZER EXPERIMENTS WITH DIFFERENT SOURCES OF PHOSPHORIC ACID.

BY H. J. PATTERSON, DIRECTOR AND CHEMIST.

The experiments reported upon in this bulletin were inaugurated in the spring of 1895. The object was to test the availability of different sources and forms of phosphoric acid and methods for rendering insoluble phosphoric acid available in the soil.

Before proceeding with the description of the plan of the experiments and the discussion of the results, it will probably be best to devote a little space to the general consideration of the subject of phosphoric manures, the forms in which phosphoric acids exists, and various sources and methods of manufacture of the same.

*Phosphoric Acid or Phosphates*:—Phosphorous compounds are absolutely necessary for the maturity of plants and the formation of seed for their reproduction. It has been well established that the salts of phosphoric acid, or phosphates, as they are called, are the only sources from which the phosphorous of plants can be derived. Phosphoric acid is a combination of the element Phosphorous (P) with Oxygen gas (O). In phosphates the phosphorous and oxygen unite in the proportion of two parts of the former to five of the latter forming what is commonly designated as *phosphoric acid*, and this union is expressed by the sign or sombol $P_2O_5$. Phosphorous, when uncombined with other elements, is a yellowish, waxy looking, solid substance. It is soft and can be cut as easily as ordinary bees-wax. It is very poisonous. It ignites easily and therefore has to be kept under water. When phosphorous burns it simply unites with the oxygen of the air, forming phosphoric acid ($P_2O_5$).

Phosphoric acid usually occurs in the soil in combination with lime, magnesia, alumina and iron. These phosphates are all practically insoluble in water; that is they are dissolved by pure water so slowly and to so slight an extent that they sustain no appreciable loss in the soil by drainage water. Hence the quantity in the soil is diminished almost wholly through the agency of crops. The amount of phosphoric acid even in a fertile soil is comparatively small. A ton of good soil will contain about 3 pounds; many will contain less, and some considerably more. On this basis an acre of average soil would contain to the depth of 9 inches, about 4,500 pounds of phosphoric acid. An analysis of the nothing plots showed the soil used for the experiments reported in this bulletin to have

weighed about 1,812,964 lbs. per acre to the depth of six inches and to have contained 2719 lbs. phosphoric acid. A large portion of this is not available to crops. The character of the soil affects very considerably, the available condition of the plant food. One of the problems that confronts the farmer is to use such methods in soil management as will convert the plant foods which the soil contains, into forms available for crops.

### FORMS OF PHOSPHORIC ACID.

As has already been stated, phosphoric acid exists in soils in combination with lime, magnesia, alumina and iron, and it is in these same combinations in which it is found in the various sources from which phosphates are manufactured. For the manufacture of fertilizer and in agriculture, the phosphate of lime is most highly prized and preferred.

In nature the phosphates are found in a form, termed *insoluble*, which means that they are practically insoluble in water.

In manufacturing fertilizer from phosphate of lime the aim has been to change it from the insoluble condition to a soluble condition which would be more available to plants. In the natural and insoluble state the phosphate exists in what is chemically known as *tricalcium phosphate*, (three-lime phosphate), and in the course of manufacture this is changed chemically so that, at the end of the operation, there exists four kinds or combinations of Calcium (lime) and phosphoric acid, which are as follows:

(1) Soluble phosphate of lime, or mono-calcium phosphate.
(2) Reverted phosphate of lime, or di-calcium phosphate.
(3) Insoluble phosphate of lime, or tri-calcium phosphate.
(4) Tetra-calcium phosphate, or four-lime phosphate.

### (1) SOLUBLE PHOSPHATE OF LIME.

This is properly known under several other names as "Superphosphate," "Superphosphate of lime," "Acid phosphate," "Acid phosphate of lime," "Water soluble phosphate," "Acid calcium phosphate," Mono-Calcium phosphate," and "One lime phosphate." Phosphoric acid does not occur naturally in the soluble state.

Soluble phosphoric acid is made by treating bones or mineral phosphates with sulphuric acid (oil of vitriol). The chemical change which occurs is practically as follows: Sulphuric acid and water being applied to the materials containing insoluble phosphates (tri-calcium phosphate), the sulphuric acid combines chemically with two parts of lime and forms sulphate of lime or gypsum (land plaster), which the water unites with the phosphoric acid and one part of lime, forming mono-calcium or soluble phosphate of lime. The substances being mixed, it is a natural chemical action or reaction that takes place with the result stated. The total conversion of the insoluble to the soluble form, cannot be accomplished without using such an excess of sulphuric acid as would be injurious to seeds and roots of plants which would come in contact with the fertilizer, and also would make the fertilizer of such a mechanical condition as to be difficult to handle and apply. In practice, less acid is added than is necessary to wholly convert all the phosphoric acid to the soluble

form, consequently more or less of all the forms of phosphoric acid are found to be present after the fertilizing materials have been treated or dissolved. Liebig in 1840 was the first person to suggest the treatment of bones and mineral phosphates with sulphuric acid, for the purpose of rendering the phosphoric acid available for plants. This may be said to be the beginning of the use of genuine artificial fertilizers. In the course of dissolving phosphates some of the phosphoric acid is set entirely free and will be found as free phosphoric acid in freshly made goods, but this will remain so for only a comparatively short time. It will in time act on the insoluble phosphates contained in the fertilizer. The water-soluble phosphoric acid is readily distributed in the soil, and is in a form that can be immediately absorbed by roots and used by plants as food, but unfortunately the water-soluble phosphoric acid will not remain long in the soil in this condition, for, on coming in contact with the lime, magnesia &c., in the soil, it reverts to a condition insoluble in water. In reverting, this water-soluble phosphoric acid is precipitated in such a way as to form a fine powder or coat over the particles of soil, and is thus in a finely divided state and presents a considerable surface which makes it easily dissolved by the soil waters, or the acid exudations of rootlets and thus still possesses a greater availability than any other form of phosphoric acid.

## (2) REVERTED PHOSPHATE OF LIME.

Reverted phosphate of lime, also spoken of as "Reverted phosphoric acid," "Reverted calcium phosphate," "Precipitated phosphate of lime," "Citrate soluble phosphate," "Neutral phosphate of lime," and "Di-calcium phosphate," is quite insoluble in pure water, but is easily dissolved in water containing carbonic acid or salts of ammonia and in weak acids. The term *reverted* was originally intended to imply that this phosphoric acid had once been soluble, but for some cause, had "gone back" to a form insoluble in water. This probably does take place to a limited extent, but as a matter of fact in the course of manufacture there is not sufficient acid used to make all the phosphoric acid soluble, and some of the tri-calcium phosphate loses only one part of lime, and thus leaves some di-calcium phosphate remaining. As has been stated some phosphoric acid is set entirely free which will unite with available phosphoric acid and bring some of it to the so-called reverted form. This form of phosphoric acid is readily assimilated by plants, because the soil and solutions from the plant roots usually contain acids strong enough to dissolve it. Reverted phosphoric acid is therefore considered nearly as valuable as a plant-food as the water-soluble form. Reverted phosphoric acid is often met with in small quantities in nature in connection with some insoluble phosphates, guanos, limes and other organic matter.

## AVAILABLE PHOSPHORIC ACID.

In the commercial world and in stating the results of an analysis, the percentage of soluble phosphoric acid and the reverted or citrate soluble phosphoric acid are added together and the sum called *available phosphoric acid.*

### (3) INSOLUBLE PHOSPHORIC ACID.

This is known under several names; as "Insoluble calcium phosphate;" "Tri-calcium phosphate," "Bone phosphate of lime," and "Normal calcium phosphate." This form is called insoluble because it does not dissolve in water or weak acids as does the soluble or reverted phosphoric acid; but requires some strong acid to cause its decomposition or solution.

Insoluble phosphoric acid is found in nature in large quantities some of the chief sources of which will be noticed later.

Insoluble phosphates are found everywhere in the soil and most of them are of but little value to the farmer because they are not easily dissolved and can therefore be utilized but slowly by plants. One of the chief points under experimentation and reported upon in this bulletin, was to test means for rendering these insoluble phosphates available to plants through the agency of crops and cultivation without the intervention or use of sulphuric acid.

### (4) TETRA-CALCIUM PHOSPHATE.

Tetra-calcium phosphate, or four-lime phosphate, is a form of phosphoric acid of recent discovery, and has been found to exist in slag phosphates. It contains more lime in proportion to phosphoric acid than any other form of phosphate. While it is insoluble in water, it has been found to be more available to plants than insoluble phosphate of lime (tri-calcium phosphate.)

The following table gives the chemical composition and differences of the four phosphates of lime:

TABLE I.

*Chemical Composition of the Four Phosphates of Lime.*

| | Calcium per cent | Phosphorous per cent | Oxygen per cent | Hydrogen per cent |
|---|---|---|---|---|
| 1 Soluble Phosphate of Lime. | 17.1 | 26.5 | 54.7 | 1.7 |
| 2 Reverted Phosphate of Lime, | 29.4 | 22.8 | 47.0 | 0.8 |
| 3 Insoluble Phosphate of Lime | 38.7 | 20.0 | 41.3 | — |
| 4 Tetra-Calcium Phosphate. | 43.7 | 17.0 | 39.3 | — |

Or stating it in another way:

| | Phosphoric Acid $P_2O_5$ | Lime CaO | Water $H_2O$ |
|---|---|---|---|
| 1 Soluble Phosphate of Lime, | 60.68 | 23.93 | 15.39 |
| 2 Reverted Phosphate of Lime, | 52.20 | 41.18 | 6.62 |
| 3 Insoluble Phosphate of Lime, | 45.81 | 54.19 | —— |
| 4 Tetra Calcium Phosphate. | 38.79 | 61.21 | —— |

### TOTAL PHOSPHORIC ACID.

Total phosphoric acid is the sum of all the forms of phosphoric acid which a given fertilizer contains. In ordering dissolved rock, for in-

stance, the total is equal to the sum of the soluble, reverted, and insoluble phosphoric acid contained therein.

## METHOD OF MANUFACTURING SOLUBLE PHOSPHATES.

The process of manufacturing soluble phosphates from bones or mineral phosphates is not very complicated, yet requires some chemical knowledge and experience, and facilities for carrying on the operation.

The raw phosphates, whether of animal or mineral origin, are quite variable in their physical condition and chemical composition; yet the phosphoric acid will be found to be combined with lime, in the proportion of one part of the former to three of the latter forming the tricalcium phosphate.

The chief result which the manufacturer desires to arrive at is to make the tri-calcium phosphate soluble in water or in neutral ammonium citrate. To do this the chemist has worked upon the following basis: Sulphuric acid is known to be more energetic in its action at ordinary temperature than any other acid used in industry. It, therefore, has the power of displacing all other acids from their salts, and of taking their bases to itself to form sulphates; which, for the most part, are quite staple and easily handled substances. The acids chiefly present in natural phosphates are phosphoric, carbonic, flouric, and silicic. These, when brought in contact with dilute sulphuric acid, are all displaced, and the bases become sulphates. Chemists have determined how much sulphuric acid is required to displace each of the various acids present, and to form sulphates with the bases with which they are combined; so that, after the composition of a natural mineral phosphate has been determined, the amount of sulphuric acid of a given strength which it is necessary to use in order to bring about the desired change of a tri-calcium phosphate to the soluble and reverted forms, can be easily calculated. These amounts have been worked out for practice as expressed in the following table:

TABLE II.*

*One Part by Weight of Each Substance Below Requires.*
*Sulfuric Acid by Same Unit of Weight.*

| | At 48° B. | At 50° B. | At 52° B. | At 54° B. | At 55° B. |
|---|---|---|---|---|---|
| Tricalcium Phosphate, | 1.590 | 1.517 | 1.446 | 1.382 | 1.352 |
| Iron Phosphate, | 1.630 | 1.558 | 1.485 | 1.420 | 1.390 |
| Aluminum Phosphate, | 2.025 | 1.930 | 1.839 | 1.756 | 1.721 |
| Calcium Carbonate, | 1.640 | 1.565 | 1.495 | 1.428 | 1.411 |
| Calcium Fluoride, | 2.060 | 2.010 | 1.916 | 1.830 | 1.794 |
| Magnesium Carbonate, | 1.940 | 1.860 | 1.775 | 1.690 | 1.660 |

*W. H. Wiley's "Principles and Practice of Agricultural Analysis", Vol. II, p. 155

*Example.*—Suppose for example a phosphate of the following composition is to be treated with sulfuric acid ; *viz :*

| | | |
|---|---|---|
| Moisture and organic | 4.00 | per cent. |
| Calcium phosphate | 55.00 | " |
| Calcium carbonate | 3.00 | " |
| Iron and Aluminum phosphate, nearly all Alumina | 6.50 | " |
| Magnesium Carbonate | 0.75 | " |
| Calcium Fluoride | 2.25 | " |
| Insoluble | 28.00 | " |

Using sulfuric acid of 50° B., the following quantities will be requiredfor 100 kilograms.

| | Kilos of acid r quired. |
|---|---|
| Calcium Phosphate, fifty-five kilos | 83.44 |
| Calcium carbonate, three and a half kilos | 5.48 |
| Calcium fluoride, two and a quarter kilos | 4.52 |
| Aluminum and iron phosphate, six and a half kilos | 12.55 |
| Magnesium carbonate, three-quarters of a kilo | 1.40 |
| Total | 107.39 |

The material before treatment is always finely ground so as to facilitate the chemical action. After the treatment has been completed the mass is dried and ground for use.

The materials which are chiefly used as sources of phosphoric acid in fertilizer and given in the following table together with their average composition. A more detailed description of those marls which were used in the experiments under consideration will be given later.

TABLE III.

*Giving the Approximate Amount of Phosphoric Acid in Fertilizing Materials.*

| Materials Containing Phosphoric Acid. | Phosphoric Acid ($P_2O_5$) Soluble per cent. | Reverted per cent. | Insoluble per cent. | Total per cent. | Lbs. in one ton. Available Phosphoric Acid | Total Phosphoric Acid |
|---|---|---|---|---|---|---|
| Apatite, | ..... | ...... | ...... | 38.0 | ...... | 760 |
| Bone ash, | ..... | ...... | ...... | 35.9 | ...... | 718 |
| Bone black, | ..... | ...... | ...... | 28.3 | ...... | 567 |
| Bone-black (dissolved) | 16.0 | 0.7 | 0.3 | 17.0 | 334 | 340 |
| Bone-meal, | 0.4 | 6.5 | 15.6 | 22.5 | 138 | 450 |
| Bone-meal (from glue factory) | ...... | 6.5 | 22.4 | 28.9 | 130 | 578 |
| Bone-meal (dissolved) | 10.0 | 5.0 | 2.5 | 17.5 | 300 | 350 |
| Caribean guano, | ..... | ...... | ...... | 18.9 | ...... | 378 |
| Cuban guano, | ..... | ..... | ...... | 17.9 | ...... | 358 |
| Double supershosphate, | | | 4.0 | 44.0 | 800 | 880 |
| Florida rock, | ...... | ...... | ...... | 30.0 | ...... | 600 |
| Fla. soft phosphate, | ...... | ...... | ...... | 24.0 | ...... | 480 |
| Keystone concentrated phosphate, | 0.3 | 38.2 | 9.2 | 47.7 | 770 | 950 |
| Mona Island phosphate, | ...... | 7.5 | 14.3 | 21.8 | 150 | 436 |
| Navassa phosphate, | ...... | ...... | ...... | 34.3 | | 686 |
| Orchilla guano, | ...... | ...... | ...... | 26.8 | ...... | 536 |
| Peruvian guano, | 4.6 | 3.8 | 4.9 | 13.3 | 168 | 266 |
| South Carolina rock (ground) | ...... | 0.3 | 27.7 | 28.0 | 6 | 560 |
| South Carolina rock, (floats) | ..... | 0.5 | 27.5 | 28.0 | 10 | 560 |
| South Carolina rock, (dissolved) | 10.5 | 3.5 | 2.0 | 16.0 | 280 | 320 |
| Slag phosphate, (American) | ...... | ...... | ...... | 21.0 | ...... | 420 |
| Slag phosphate, (German) | .... | ..... | ...... | 30.0 | ...... | 600 |
| Tenn. Phosphate rock, | ...... | ...... | ...... | 35.0 | ...... | 700 |

## IMPORTANCE OF PHOSPHORIC ACID TO CROPS.

It has already been stated that Phosphoric acid was very necessary to the growth of crops and particularly essential to the maturity of seed, which is evidenced by the percentages given in table 4.

Though there is little loss of phosphoric acid from soils through any source except that removed by crops, yet they draw on the soil to a considerable extent. The amounts removed by crops is much more than would be expected from a simple examination of the percentage content.

The drain of phosphoric acid from the land by the principal crops raised in Maryland is shown by the figures in table 4. Though large as these figures seem, yet there is much more removed by the one-and-one-half million dollars worth of truck crops and small fruits annually sold from Maryland farms that is not accounted for in the table. Again the live-stock, poultry and eggs annually sold carry considerable phosphoric acid with them. The total removed by the crops, as reported in the table, of 25,324,084 pounds would require, if it were to be replaced, over ninety-thousand tons of standard dissolved phosphate rock. This would mean an expenditure of over a million dollars annually for this one plant-food alone.

TABLE IV.

*The Approximate Quantity of Phosphoric Acid Annually Removed from Maryland Farms by the Principal Crops.*

(*Compiled From Yields of* 1899.)

| CROPS. | Bushels | Weights in pounds | Per cent. Phosphoric Acid. | Wgt. of Phosphoric Acid in pounds. |
|---|---|---|---|---|
| Wheat grain, | 10,710966 | 642,657,960 | 0.81 | 59,19,655 |
| " straw, | ..... ........ | 1,092,518 532 | 0.12 | 1,211,022 |
| Corn grain, | 18,562432 | 1,039,496,192 | 0.70 | 7,276,473 |
| " fodder, | ............ | 2,078.992,384 | 0.29 | 6,029,077 |
| Oats grain, | 1,675,596 | 53,619,072 | 0.82 | 438,676 |
| " straw, | ......... . | 91,152,422 | 0.20 | 182,304 |
| Barley grain. | 18,778 | 901,824 | 0.79 | 7,124 |
| " straw, | ............. | 1,533,100 | 0.30 | 4,599 |
| Rye grain, | 353,276 | 19,783,456 | 0.82 | 162,224 |
| " straw, | ............ | 33,631,875 | 0.28 | 94,169 |
| Buckwheat grain, | 97,630 | 4,686.240 | 0.44 | 20,619 |
| " straw, | ............. | 7,966,608 | 0.61 | 48,596 |
| Hay (tons), | 31,978 | 639,562,000 | 0.45 | 2,878,029 |
| Irish potatoes, | 1,420,352 | 85,221,120 | 0.07 | 59,654 |
| Sweet potatoes, | 408,549 | 24,512,940 | 0.08 | 21,610 |
| Tobacco, | ............. | 12,356,838 | 0.55 | 67,962 |
| Fruits, | 2,288,759 | 162,994.155 | 0.02 | 32,598 |
| Milk, | ............ | 619,498,732 | 0.17 | 1,053,147 |
| Clover Seed, | 11,258 | 675 480 | 1.45 | 9,794 |
| Grass Seed. | 7,748 | 309,920 | 0.85 | 2,634 |
| Beans and Peas, | 6,167 | 370,020 | 0.84 | 3,108 |
| Total, | | | | 25.324,083 |

## PLAN OF THE EXPERIMENTS CONDUCTED.

The general plan of the experiments, as already stated, consisted in the testing of the availability of different forms of phosphoric acid and means for rendering insolnble phosphates available in the soil. The idea in mind was to make these tests much more than a soil test of the particular farms, but they were so planned and conducted as to make the results applicable to most parts of this state, and of general interest to agriculture wherever commercial fertilizers are used.

The general idea that pervaded the plan was to imitate natnre and get the land as nearly as possible in the same condition it was when a virgin soil and then continue to use natures methods for maintaining fertility.

It is well known from chemical analysis of soils that they contain sufficient phosphoric acid to furnish all that is needed for good crops for many years. It has also been shown that some soils which fail to produce satisfactory crops contain more phosphoric acid than those that are considered fertile. Now this difference in fertility must be due to a condition of availability.

An examination of the conditions which prevailed in virgin soils, or in any soil that has just been cleared of its forest growth, soon makes

prominent the fact that nature has filled that soil with organic matter; this organic matter not only gives the soil a dark color and fine physical appearance but it also performs functions in producing chemical changes that cannot take place in that same soil were it destitute of organic matter. Again we find that a virgin soil will produce satisfactory crops for a number of years without the intervention of commercial fertilizers; but about as soon as the organic matter has been worked out, the soil fails to produce satisfactory crops, and the use of phosphates is resorted to.

Now the phosphoric acid which these soils contained was not in a form soluble in water, nor was it in the form of *reverted* or di-calcium phosphates but it was an insoluble phosphate of lime, magnesia, iron or alumina. Though termed insoluble, yet this phosphoric acid was available to crops, through the chemical changes made possible by the presence of organic matter and the compounds formed through its decomposition. It was the water charged with carbonic, humic and other organic acids, formed by the decomposition of vegetable matter, that was able to dissolve the insoluble phosphates of the virgin soils and place them either directly at the disposal of crops, or form such combimations as could be utilized thereafter.

As soon as the organic matter of the soil was used up these favorable conditions no longer obtained, and crops could not avail of the natural properties of the soil even though there was an abundance there. Now if nature's methods are observed again, it will be noticed that wherever she is producing vegetation she has devised means for depositing some vegetable matter in the soil in about the same proportion as she produces.

Taking all these facts into consideration would in not seem reasonable that, in order to avail properly of the phosphates contained naturally in the soil, that it would be necessary to imitate Nature's methods and fill the soil with organic matter. Then again could not the phosphoric acid contained in the mineral phosphates be rendered available in the soil through the agency of organic matter if these phosphates were applied in their natural state except being pulverized? If these questions can be answered in the affirmative, and the farmer can arrive at an economical and satisfactory method of providing the requisite amount of organic matter in the soil, then it will be possible to avail of the phosphates already in the soil; and thus, on some lands, make it necessary to purchase phosphoric acid. When recourse to purchase becomes necessary, then a cheaper form of phosphoric acid can be used and do away with paying out so much money for dissolved or acid treated phosphates, which in the end is practically a means of accomplishing or arriving at a mechanical condition.

These are the ideas that call for the planning and management of the experiments outlined in the following program:

## TABLE V.

*Phosphoric Acid Experiments.*

*(Plots One-Tenth of an Acre Each.)*

| Plot No. | Kind of Fertilizer and Treatment. | Quantity* Per plot. | Quantity Per acre. |
|---|---|---|---|
| | Crimson Clover Seeded in Corn. | Lbs. | Lbs. |
| 1 | Double Superphosphates (Soluble $P_2O_5$), | 32 | 319 |
| 2 | Dissolved Bone-black (Soluble $P_2O_5$), | 73½ | 735 |
| 3 | Dissolved S. C. Rock (Soluble $P_2O_5$). | 100 | 1000 |
| 4 | Double Superphosphates (Reverted $P_2O_5$), | 37 | 370 |
| 5 | Nothing, | ... | . . |
| 6 | Iron Alumina Phosphate (Reverted $P_2O_5$), | 37 | 370 |
| 7 | Bone-black, (Insoluble $P_2O_5$), | 51½ | 514 |
| 8 | Raw Bone meal, (Insoluble $P_2O_5$), | 66⅔ | 667 |
| 9 | Slag Phosphate, (Insoluble $P_2O_5$), | 92 | 920 |
| 10 | Nothing. | ... | ...... |
| 11 | Ground S. C. Rock, (Insoluble $P_2O^5$), | 53 | 530 |
| 12 | Florida Soft Phosphate, (Insoluble $P_2O_5$), | 56 | 560 |
| | Corn-ground left bare during Winter. No Green Crop Turned Under. | | |
| 13 | Same as No. 8. | 66⅔ | 667 |
| 14 | Same as No. 9. | 92 | 920 |
| 15 | Nothing, | ... | ...... |
| 16 | Same as No. 11, | 53 | 530 |
| 17 | Same as No. 12, | 56 | 560 |
| | Rye Seeded on Corn Ground. | | |
| 18 | Same as No. 8, | 66⅔ | 667 |
| 19 | Same as No. 9, | 92 | 920 |
| 20 | Nothing, | ... | . |
| 21 | Same as No. 11, | 53 | 530 |
| 22 | Same as No. 12, | 56 | 560 |

*These quantities give each plot the same quantity of Phosphoric Acid, (150 pounds per acre, which was determined by analyzing the materials used.)

The piece of land used for these experiments lies north of the Experiment Station buildings and along the fence west of the pike. This land is a moderately stiff clay, naturally quite well drained though fairly level. The general character of the plots runs quite uniform, in fact more so than most pieces of like area in this formation.

The history of the cropping of the land used for this test was, so far as known, as follows: in 1888 there was a poor stand of grass and weeds on this land, which was plowed down and seeded to wheat which was harvested in 1889; grass 1890-91; corn 1892; fallowed 1893, and in wheat 1894—clover and timothy seeded in wheat and gave a good set.

Plots were numbered commencing at end next Experiment Station building, toward Paint Branch.

## DESCRIPTION OF FERTILIZERS USED IN THE EXPERIMENTS.

A detailed description of all the materials mentioned in table 3 can be found in Bulletin No. 6 of this Station, so that a description of only those used in the test outlined in table 5 will be given here. These will be described in the order of the plot numbers.

The materials used were selected with reference to giving all the forms of phosphoric acid found in fertilizers and so as to have them furnished by the chief sources of phosphoric acid on the market at the time the experiment was inaugurated. Plots Nos. 23 to 28 were reserved for making additions to the list whenever it would seem desirable to do so.

*Plot No.* 1.—*Double Superphosphate.*—This, as its name indicates, is a concentrated form of soluble phosphoric acid. It is made by dissolving mineral phosphates in phosphoric acid instead of sulphuric acid. The process of manufacture consists of treating a low grade of phosphate rock, or those too poor in phosphoric acid to make a high grade or standard superphosphate, with an excess of dilute sulphuric acid. This sets free the phosphoric acid, which, together with the excess of sulphuric acid, is removed and separated from the insoluble materials by filtration and washing. The acid solutions thus obtained are concentrated and then used for dissolving the better class of phosphate rock. Because the acids used for dissolving the phosphates contain phosphoric acid, the product yielded contains more than double the amount of phosphoric acid in the ordinary product.

Double superphosphate is manufactured to some extent in this country but mostly in Europe. Its use in this country is not as great now as it was a few years ago. This was selected as one of the sources of phosphoric acid, as it contains a minimum of impurities and a maximum of phosphoric acid in the soluble form.

*Dissolved Bone Black* (*Plot* 2) *and Bone Black* (*Plot* 7)—When broken bones are placed in a retort or iron cylinder, the air being excluded, and then strongly heated; gas, water, oily matters and other products are driven off, while black bone charcoal is left. This product, also known as bone-black and animal charcoal, is used extensively in sugar refineries for taking the coloring matter out of raw sugars. From time to time portions of the bone charcoal cease to be effective in clarifying and the spent black is then sold by the refineries for fertilizing purposes. All the phosphoric acid originally in the bones is retained, but the presence of carbon prevents the phosphate from decomposing. It is as "dissolved bone-black" that this article is generally found on the market. Dissolved bone-black contains a large proportion of soluble phosphoric acid and a very small amount in the insoluble form. Dissolved bone-black was applied on plot No. 2, and the untreated bone-black on plot No. 7.

*Dissolved South Carolina Rock, Plot, No.* 3 :—This constitutes by far the greater bulk of the materials now used in this country for making phosphate manures. An immense trade has grown up in this class of

phosphates during the last thirty years. The most common name by which this class is known is "Acid Phosphate," but it is also found on the market as Dissolved S. C. Rock, Dissolved S. C. Bone, and Bone Phosphate Rock. While the rock which was first used for making this class of fertilizers was first found in South Carolina, yet much of it now comes from deposits in Florida and Tennessee. The dissolved phosphates of this class contain a large portion of their phosphoric acid in the available condition, but not quite as much in the soluble form as in dissolved bone-black.

*Plot* 4. *Reverted Phosphate of Lime*:—The phosphate applied on this plot had for its base some of the same double superphosphate used on plot No. 1, with which had been mixed, before application, sufficient lime to change the phosphoric acid from the soluble to the reverted state. This was used in the hopes of procuring some *data* from the crops as to the relative availability of phosphoric acid in the soluble and reverted form.

*Plot No.* 6. *Reverted Phosphate of Iron and Alumina*:—This plot was added so as to give an opportunity for comparing fertilizers which contained the phosphoric acid largely in combination with lime (Plot 4) with those that had it principally in combination with iron and alumina. The material applied to this plot was what is known on the market as "Keystone Concentrated Phosphate," and was being extensively manufactured and sold about the time these tests were planned, but has gone almost, if not entirely, out of the market now.

*Plot No.* 7. *Bone-Black.*—Insoluble phosphoric acid. Description given under plot No. 2.

*Plot No.* 8 *Raw Bone, Ground Bone or Bone Meal.*—Animal bones are composed of two distinct substances, which interpenetrate one another. There is a sort of frame-work of earthy matter, which is phosphate of lime or bone phosphate, and a fleshy filling called ossein, which is a substance containing much nitrogen. Raw bones are, therefore, doubly valuable for manurial purposes, because they contain both phosphoric acid and nitrogen. As ordinarily collected, bones contain from 50 to 60 per cent. of phosphate of lime and from 5 to 7 per cent. of nitrogen. Fresh raw bones also contain fat, and this is not only useless as a plant food but it adds weight to the bone and makes it hard to grind; and when ground, the more fat remaining in the bone, the slower will be the decomposition in the soil. To obviate this difficulty bones are generally steamed, or carried through some process to remove fat, before they are ground for fertilizers. Steamed or dessicated bones, if not too strongly steamed, are better for fertilizer than raw bones. Some nitrogen is lost by these processes, but if carefully done, the gain exceeds the loss. Bone-meal is obtained by grinding the crude or steamed bones, and it is valuable in proportion to the degree of fineness to which it is reduced. According to its fineness, it is variously called ground-bone, bone-meal, flour-of-bone and bone-dust. The finer it is, if used without acid, the easier it decays or dissolves in the soil and the sooner the chemistry of nature converts the (tri-calcic) phosphate of lime to a form available to plants. Good ground bone or bone-meal should contain from 20 to 25 per cent. of phosphoric acid and from 3 to 4 per cent of nitrogen.

The demand for bones for use in various arts and especially in refining sugar, is making this form of fertilizing material comparatively scarce in the market and correspondingly high in price. If rates advance much it will become unprofitable for farmers to use bone fertilizers for their phosphates. The same causes lead to the considerable adulteration of bone-meal that is now found. Lime, gypsum, coal-ashes, ground oyster shells, crab shells, and like articles are used for this purpose as well as the less-objectionable mixing of fine-ground rock phosphate, all being sold under the name of bone. When bone, ground bone, or bone-meal is treated with sulphuric acid, the product is the dissolved bone of our markets, also known as acidulated bone, soluble bone and dissolved bone phosphate. This is simply an acid phosphate or superphosphate, made from bones.

*Plot No. 9. Slag Phosphate, Basic Iron Slag, or Thomas Slag-Meal.*— To these names may be added *Thomas Scoria* and *Odorless Phosphate*, all given to a waste material or slag, which is a by-product in the preparation of steel, by what is known as the "basic process." The object of this process is the extraction of phosphorous from pig iron, by means of a basic lining of the converter invented by Jacob Reese. The product of the process is a substance containing from 15 to 20 per cent. of phosphoric acid. It is metallic in appearance but may be ground forming a dark brown meal. The phosphoric acid is in combination chiefly with lime, as tetracalcium phosphate ; it is insoluble in water, slightly soluble in ammonium citrate, and is, by ordinary methods of analysis, classified largely as insoluble. Yet its condition is such that soil water, when charged with carbonic acid, will dissolve it to a considerable degree. Thomas Slag is largely used and highly valued in Germany, and is the cheapest form in which phosphoric acid can be obtained by the farmers of that country. Eminent German experimenters have lately spoken strongly in its favor. Wagner states that two pounds of this material, ground fine, (but no acid treatment), containing 18 per cent. phosphoric acid and no other valuable plant food, and costing 4½ cents, produced the first year after its use, the same increase in yield as one pound of soluble phosphoric acid from bonemeal costing 6½ cents. And in the second year the effect of the Thomas Slag was twice that of the other. These are important facts, but the place of this slag phosphate among the commercial phosphates of this country has yet to be determined.

This material gets the name by which it is best known in Europe, from S. G. Thomas of England, who claimed to be the prior inventor of the basic process of making pure steel. This claim was disputed by Jacob Reese of Pennsylvania, and the courts of this country have confirmed the claim of Reese. The slag is now manufactured by the latter in large quantities at Pottstown, Penn., and is sold under the name of Odorless Phosphate. This is the slag very finely pulverized but not treated with acid. An idea of the growth of the consumption of slag phosphate may be gotten from the following report showing its production :

TABLE VI.

*Slag Phosphate Produced.*

| | Tons. |
|---|---|
| 1878 | 4 |
| 1879 | 360 |
| 1880 | 15,000 |
| 1881 | 100,000 |
| 1882 | 135.000 |
| 1883 | 190,411 |
| 1884 | 259.000 |
| 1885 | 283,495 |
| 1886 | 412,505 |
| 1887 | 511,344 |
| 1888 | 585,970 |
| 1889 | 682.365 |
| 1890 | 783,924 |
| 1891 | 720 134 |
| 1892 | 800,660 |
| 1893 | 874.000 |
| 1894 | 896,301 |
| 1895 | 934,235 |
| 1896 | 962 050 |
| 1897 | 1,033,002 |

*Plot No.* 11. *Ground South Carolina Rock; (Insoluble Phosphoric Acid) :*—The material applied to this plot is the natural phosphate finely ground and just in the same condition in which the manufacturers put it before treating with acid. The phosphoric acid is chiefly in the state of the tri-calcium phosphate. If this ground rock could be successfully used so as to give satisfactory crops, the cost of a pound of phosphoric acid would be reduced over one half. These mineral phosphates are chiefly obtained from immense natural deposits in North Carolina, Georgia and Florida, and generally in the rivers and low lands along the coast. Bones and fossil teeth were dug up in a swamp near the Cooper river almost a hundred years ago, but the extent of the deposits and their economic value have been developed within thirty-five years.

The most prominent characteristic of the native phosphate is its nodular form. Even where the deposits occur as an apparently smooth and compact layer, or in large flat cakes, it is nevertheless composed of irregular nodules, partially cemented or compact together. Nearly all these nodules have the egg or kidney shape. The exterior is sometimes rough and indented, often honey-combed with round or irregular holes, and sometimes it is smooth and compact. The surface is occasionally shiney and coated as if with enamel. Fossill shells, fish bones and teeth are not infrequently found embedded in the nodules, and other animal remains occur in the same general deposits. The nodules vary in size from the fraction of an inch to several feet in diameter,and in weight from almost a ton, downwards. When found, as much of this deposit is, in river bottoms or under marsh-mud, the color of the material is a grey or bluish-black. The land rock is usually of a lighter color, yellowish or greyish white. The masses are easily broken and ground to a fine powder, light yellow or grey, often becoming so light as to float in the air. In this extremely fine condition, and before being treated with acid, the material is often called *Floats*. There is no reasonable doubt that these phosphates

came from the remains of both marine and land animals, although it would be out of place to give the evidence here. A long series of geological transformations is envolved, together with different eras of animal life and subsequent changes in the mineral matters themselves. From several hundred analyses of the raw or simply ground Carolina rock, the mineral has been found to contain on an average from 25 to 28 per cent. of phosphoric acid, 2.5 to 5 per cent. of carbonic acid, 0.5 to 2 per cent. sulphuric acid, 35 to 42 per cent. lime, and a little magnesia, soda, silica, iron and other elements. The finding of the fossil bones, teeth, etc., spoken of, has led to the term "South Carolina bone" being incorrectly applied to these mineral phosphates.

*Plot No. 12. Florida Soft Phosphate; (Insoluble Phosphoric Acid)*—Florida soft phosphate is chiefly an alumina iron phosphate which occurs in large quantities deposited in many parts of that State. It is not well adapted to treatment with acid for making soluble phosphates, as the alumina and iron make a sticky mass which is hard to dry and keep in a good mechanical condition. The Florida soft rock has been largely used as a fertilizer in its natural condition in some parts of that State on the light, sandy land, giving good results. When used in this way there has been applied at the same time heavy dressings of the native mucks from the swamps and lakes. This muck furnishes nitrogen as well as the much needed organic matter. In order to have a complete fertilizer there is also applied some German potash salt.

The Florida soft phosphate was used in this test in order to compare the lime and alumina phosphates in the insoluble forms.

TABLE VII.

*Analysis of Phosphates Used on Phosphoric Acid Plots.*

| Index No. | | Total Phosphoric Acid ($P_2O_5$) Per cent. |
|---|---|---|
| 1706 | Double Superphosphate, | 47.04 |
| 1707 | Dissolved bone-black, | 20.40 |
| 1708 | Dissolved South Carolina rock, | 15.04 |
| 108 | Reverted Iron and Alumina phosphates, | 43.20 |
| 1709 | Bone-black, | 29.20 |
| 1713 | Raw bone-meal, | 22.48 |
| 1712 | Slag phosphate, | 16.32 |
| 1710 | Ground South Carolina rock, | 28.32 |
| 1711 | Florida soft phosphate, | 26.80 |

## SYNOPSIS OF TESTS UNDER CONSIDERATION.

1. Testing the principal sources of soluble phosphoric acid.

2. Comparing the availability of soluble, reverted and insoluble phosphoric acid.

3. Comparing phosphate of lime and phosphate of alumina and iron in the reverted forms.

4. Comparing the principal sources of insoluble phosphates, both in the lime, alumina aud iron compounds.

5. Comparing the tri-calcium and tetra-calcium phosphates.

6. Testing the effect which green manures and the aecumulated vegetable matter there from have, in aiding the availability of the insoluble phosphates.

7. Comparing a leguminous and a graminacious erop for the purpose of rendering insoluble phosphate available.

## RECORD OF TREATMENT AND CULTIVATION OF PLOTS, (1895).

The land was in sod when laid off into one-tenth acre plots. This was plowed in the spring and the fertilizer, as indicated by the schedule, was sown broad-cast by hand, and thoroughly incorporated with the soil by means of a spring-tooth harrow. The land was laid off in checks 3 ft. 7 in. by 4 ft.; the corn was planted by hand so as to insure the same number of grains to a hill. There were more grains put to a hill than stalks desired, to insure a uniform stand, and the extra stalks pulled out when they were fairly well started. Corn was planted May 25th and cultivated on June 9th, 18th, 26th and July 8th. Crimson clover was seeded on plots 1 to 12 at the rate of 7 quarts per acre on July 30th. Corn was cut September 19th. Plots 18 to 22 were seeded to rye at the rate of two bushels per acre on October 18th. Corn was husked and housed on November 4th to 7th.

## (1896.)

Notes taken on the crops growing on the plots on May 6th showed no perceptible differenee in the stand of elover on the plots, with the exception of No. 3, whieh was not quite so good. The stand of rye on plots 18 and 19 was very much better and further advanced than that on the other plots. It stood considerably higher and was well headed out. The stand on the other plots was uneven and just beginning to head. Plot No. 21 was a little better than plots 20 and 22. The clover on the plots was allowed to come in full head and then plowed under on May 14th. The land was then rubbed down and allowed to stand until May 25th before being planted, so that the vegetable matter might partially decompose. Phosphoric acid fertilizers were applied May 26th to the plots according to the schedule and in addition all the plots received an application of Muriate of Potash at the rate of 100 pounds per acre. The fertilizers were sown broad-cast by hand and harrowed in. Corn was planted by hand on May 26th in rows 3 ft. 9 in. apart and 22 inches apart in the hill. The corn was thinned so as to have one stalk to the hill. Corn was cultivated June 10th, 20th and July 6th. Crimson clover seed in plots 1 to 12 on July 18th. Corn cut September 14th and 15th. Rye seeded on plots 18 to 22 on Cetober 6th at the rate of 1½ bushels per acre.

## (1897)

On May the 10th the notes taken on plots showed the same relative condition as to the growth of clover and rye on plots as was noted on May

6th, 1896. Plowed rye down on May 10th and crimson clover on May 11th. These plots were rubbed down and allowed to stand until May 29th, when the phosphoric acid fertilizers were applied and the land prepared and planted to corn. Rows 3 ft. 9 in. and hills 15 inches apart in the row. One stalk to the hill. Plots were cultivated June 16th, July 3d and 17th. Crimson clover seeded July 17th. Cut corn on September 22d. Rye seeded on plots 18 to 22 on October 18th at the rate of two bushels per acre.

(1898)

May 11.—Notes show no difference in the stand of clover on plots 1 to 12, and the rye showed some difference as was noted on May 6, 1896. Plowed down rye on plots on May 11th and crimson clover on plots on May 21st. May 30th, applied the phosphoric acid fertilizers to respective plots according to schedule. This was sown broad-cast by hand and harrowed in. The weather was very dry and the land did not get in good order for planting but was planted on June 8th. This came up poorly and made a very uneven stand so it was decided that the best thing would be to harrow it up, which was done on July 7th. The land was harrowed from time to time during the summer to keep down weeds and seeded to wheat on September 26th. There was no fertilizer applied at the time of seeding the wheat, but depending for the supply upon that applied for the corn crop on the May 30th previous. Fultz wheat was used on these plots, seeded at the rate of 6 pecks per acre. Timothy was also seeded at the same time, at the rate of 6 quarts per acre. In the following spring clover seed was sown at the rate of 6 quarts per acre.

(1899)

There was a marked difference in the appearance of the growth of wheat on the different plots.

Plots 1-9 ripened earlier than the balance and were cut on June 17th. The balance were cut on June 19th. All plots were hauled in and threshed July 19th.

(1900)

Grass on plots cut July 7th for hay. Timothy predominated, with a little clover. Quite free of weeds.

## YIELDS OF CROPS FROM PLOTS.

The details of the yields of the crops from the various plots for the five years are given in the following tables, 8, 10, 12, 13.

TABLE VIII,

*Yields of—Corn—From Phosphoric Acid Plots. (Figures Indicate Quantity per Acre.)*

| Plot No. | Kind of Fertilizer and Treatment. | 1895 | | 1896 | | 1897 | | Total for 3 Corn Crops. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain Bush | Fodder Lbs. | Grain Bush. | Fodder Lbs. | Grain Bush. | Fodder Lbs. | Grain Bush. | Grains on cob Lbs. | Fodder Lbs. |
| | CLOVER SEEDED IN CORN GROUND. | | | | | | | | | |
| 1 | Soluble phosphoric acid from Double Superphosphate | 46.0 | 2860 | 40.3 | 2100 | 57.9 | 3020 | 144.2 | 10094 | 7980 |
| 2 | Soluble phosphoric acid from dissolved bone-black | 38.7 | 2700 | 37.4 | 2200 | 51.1 | 2930 | 127.2 | 8904 | 7830 |
| 3 | Soluble phosphoric acid from dissolved S. C. rock | 39.0 | 2400 | 35.8 | 2340 | 43.6 | 2810 | 118.4 | 8288 | 7550 |
| 4 | Reverted phosphate of lime | 35.8 | 2420 | 37.0 | 2060 | 47.7 | 2920 | 120.5 | 8435 | 7400 |
| 5 | Nothing | 42.6 | 2580 | 42.0 | 2200 | 57.3 | 3190 | 141.9 | 9933 | 7970 |
| 6 | Reverted phosphate of iron and alumina | 45.4 | 2940 | 43.2 | 2400 | 64.9 | 3330 | 153.5 | 10745 | 8670 |
| 7 | Insoluble phosphate of lime, Bone-black | 36.9 | 2340 | 41.6 | 2160 | 58.1 | 3070 | 136.6 | 9562 | 7570 |
| 8 | Insoluble phosphate of lime, Raw bone-meal | 37.8 | 2100 | 43.0 | 2340 | 61.9 | 3320 | 142.7 | 9989 | 7760 |
| 9 | Tetra-phosphate; Slag phosphate | 38.4 | 2100 | 42.1 | 2320 | 58.4 | 2670 | 138.9 | 9723 | 7090 |
| 10 | Nothing | 39.4 | 1980 | 38.6 | 2060 | 49.4 | 2460 | 127.4 | 8918 | 6500 |
| 11 | Insoluble phosphate of lime; Ground S. C. rock | 42.4 | 2260 | 44.8 | 2360 | 60.7 | 3060 | 147.9 | 10353 | 7680 |
| 12 | Insoluble phosphate of iron and alumina; Florida soft rock | 44.0 | 2180 | 46.3 | 2580 | 63.1 | 3190 | 153.4 | 10738 | 7950 |
| | CORN GROUND BARE DURING WINTER. | | | | | | | | | |
| 13 | Same as plot 8 | 49.4 | 2760 | 49.1 | 2680 | 58.4 | 3160 | 156.9 | 10983 | 8600 |
| 14 | Same as plot 9 | 43.4 | 2120 | 44.4 | 2500 | 46.6 | 3130 | 134.4 | 9408 | 7750 |
| 15 | Nothing | 41.4 | 2460 | 44.1 | 2360 | 41.1 | 2980 | 126.6 | 8862 | 7800 |
| 16 | Same as plot 11 | 47.7 | 2620 | 45.0 | 2420 | 40.4 | 2880 | 133.1 | 9317 | 7920 |
| 17 | Same as plot 12 | 48.2 | 2700 | 42.4 | 2140 | 34.4 | 3020 | 125.0 | 8750 | 7860 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RYE SEEDED ON CORN GROUND. | | | | | | | | | |
| 18 | Same as plot 8 | 47.1 | 2520 | 40.4 | 2180 | 42.7 | 2660 | 130.2 | 9114 | 7360 |
| 19 | Same as plot 9 | 49.3 | 2800 | 45.3 | 2320 | 44.6 | 2980 | 139.2 | 9744 | 8100 |
| 20 | Nothing | 50.0 | 2900 | 43.0 | 1900 | 37.0 | 2480 | 130.0 | 9100 | 7280 |
| 21 | Same as plot 11 | 45.5 | 2460 | 41.7 | 1900 | 30.1 | 2820 | 117.3 | 8211 | 7180 |
| 22 | Same as plot 12 | 47.8 | 2760 | 34.8 | 1200 | 36.4 | 2660 | 119.0 | 8330 | 6620 |

## TABLE IX.

*Rain Fall for Period of Growth of Corn.*

| | 1895 | | 1896 | | 1897 | |
|---|---|---|---|---|---|---|
| | Inches | No. days | Inches | No. days | Inches | No. days |
| May 25th to 30th | 1.62 | 2 | .14 | 1 | .85 | 2 |
| June | 5.50 | 10 | 2.00 | 11 | 3.49 | 10 |
| July | 2.27 | 8 | 3.23 | 11 | 5.29 | 13 |
| August | 2.57 | 7 | 1.91 | 4 | 3.02 | 9 |
| Sept. 1st to 15th | 1.01 | 1 | 1.87 | 3 | 0 | 0 |
| Total, | 11.97 | 28 | 9.15 | 30 | 12.65 | 34 |

## TABLE XI.

*Showing Characteristics of Wheat, Straw and Head,* 1899.

| Plot No. | Length of Head | Length of Straw | Plot No. | Length of Head | Length of Straw. |
|---|---|---|---|---|---|
| 1 | 2½ in | 4 ft. 2 in. | 12 | 3¼ in | 4 ft. 4½ in. |
| 2 | 2¾ “ | 4 “ 4 “ | 13 | 2¾ “ | 4 “ 6 “ |
| 3 | 3 “ | 4 “ 5 “ | 14 | 2¾ “ | 4 “ 5 “ |
| 4 | 3 “ | 4 “ 5 “ | 15 | 3 “ | 4 “ 0 “ |
| 5 | 3 “ | 4 “ 5 “ | 16 | 3 “ | 4 “ 6 “ |
| 6 | 2¾ “ | 4 “ 3 “ | 17 | 3 “ | 4 “ 5 “ |
| 7 | 3 “ | 4 “ 2 “ | 18 | 2¾ “ | 4 “ 4 “ |
| 8 | 3 “ | 4 “ 3½ “ | 19 | 2¾ “ | 4 “ 4 “ |
| 9 | 3 “ | 4 “ 4½ “ | 20 | 3¼ “ | 4 “ 0 “ |
| 10 | 5 “ | 4 “ 1 “ | 21 | 3 “ | 4 “ 6 “ |
| 11 | 3¼ “ | 4 “ 3 “ | 22 | 3¼ “ | 4 “ 5 “ |

TABLE X.

*Yields of Wheat and Hay from Phosphoric Acid Plots.*
*(Figures Indicate Quantity per Acre.)*

| Plot No. | Kind of Fertilizer and Treatment. | 1899 Wheat. Grain Bu. | Grain Lbs. | Straw Lbs. | 1900 Hay Lbs. |
|---|---|---|---|---|---|
| | CLOVER SEEDED IN CORN GROUND. | | | | |
| 1 | Soluble phosphoric acid from Double super phosphate | 36.0 | 2160 | 4140 | 3900 |
| 2 | Soluble phosphoric acid from dissolved bone-black | 37.1 | 2226 | 4375 | 4200 |
| 3 | Soluble phosphoric acid from dissolved S. C. rock | 37.0 | 2220 | 2930 | 4950 |
| 4 | Reverted phosphate of lime | 31.6 | 1896 | 3550 | 4250 |
| 5 | Nothing | 22.0 | 1320 | 2580 | 4150 |
| 6 | Reverted phosphate of iron and alumina | 34.6 | 2076 | 3170 | 4800 |
| 7 | Insoluble phosphate of lime, bone-black | 25.6 | 1536 | 3415 | 4000 |
| 8 | Insoluble phosphate of lime, Raw bone meal | 34.5 | 2070 | 4100 | 4500 |
| 9 | Tetra phosphate ; Slag phosphate | 34.8 | 2088 | 4160 | 2450 |
| 10 | Nothing | 20.7 | 1242 | 2300 | 4000 |
| 11 | Insoluble phosphate of lime; Ground S. C. rock | 29.8 | 1788 | 3710 | 4400 |
| 12 | Insoluble phosphate of iron and alumina ; Florida soft rock | 30.8 | 1848 | 3800 | 4750 |
| | CORN GROUND BARE DURING WINTER. | | | | |
| 13 | Same as plot 8 | 35.5 | 2130 | 3720 | 2800 |
| 14 | Same as plot 9 | 37.6 | 2256 | 4395 | 4900 |
| 15 | Nothing | 22.0 | 1320 | 2180 | 3200 |
| 16 | Same as plot 11 | 32.8 | 1968 | 3530 | 3700 |
| 17 | Same as plot 12 | 29.1 | 1746 | 2800 | 3950 |
| | RYE SEEDED TO CORN GROUND. | | | | |
| 18 | Same as plot 8 | 36.0 | 2160 | 3890 | 4300 |
| 19 | Same as plot 9 | 36.1 | 2166 | 4030 | 3300 |
| 20 | Nothing | 22.6 | 1356 | 3345 | 4000 |
| 21 | Same as plot 11 | 31.9 | 1914 | 3285 | 4550 |
| 22 | Same as plot 12 | 30.1 | 1806 | 2800 | 3950 |

TABLE XII.

*Total Product per year In Five Years, From Phosphoric Acid Plots.*

(In pounds per acre)

| Plot No. | Kind of Fertilizer and treatment. | 1895 Total product corn; lbs | 1896 Total product corn; lbs | 1897 Total product corn; lbs | 1899 Total product wheat; lbs | 1900 Total product hay; lbs | Total product 5 crops; lbs |
|---|---|---|---|---|---|---|---|
| | CLOVER SEEDED IN CORN GROUND | | | | | | |
| 1 | Soluable phosphoric acid from double superphosphate | 6082 | 4920 | 7075 | 6300 | 3900 | 28277 |
| 2 | Soluable phosphoric acid from dissolved bone-black | 5410 | 4820 | 6470 | 6601 | 4200 | 27501 |
| 3 | Soluable phosphoric acid from dissolved S. C. Rock | 5130 | 4850 | 5860 | 5150 | 4950 | 25940 |
| 4 | Reverted phosphate of lime | 4925 | 4650 | 6260 | 5446 | 4250 | 25530 |
| 5 | Nothing | 5565 | 5140 | 7200 | 3900 | 4150 | 25955 |
| 6 | Reverted phosphate of iron and alumina.. | 6115 | 5430 | 7870 | 5246 | 4800 | 29461 |
| 7 | Insoluable phosphate of lime; Bone-blak. | 4925 | 5070 | 7240 | 4951 | 4000 | 25186 |
| 8 | Insoluable phosphate of lime; raw bone-meal | 4745 | 5350 | 7650 | 6170 | 4500 | 28415 |
| 9 | Tetra phosphate, Slag phosphate | 4790 | 5270 | 6755 | 6248 | 2450 | 25513 |
| 10 | Nothing | 4735 | 4760 | 5920 | 3542 | 4000 | 22956 |
| 11 | Insoluble phosphate of lime; ground S. C. Rock | 5225 | 5490 | 7310 | 5498 | 4400 | 27923 |
| 12 | Insoluable phosphate of iron and alumina; Florida soft rock | 5260 | 5820 | 7610 | 5648 | 4750 | 2908[illegible] |
| | CORN GROUND BARE DURING WINTER. | | | | | | |
| 13 | Same as plot 8 | 6220 | 6120 | 7250 | 5850 | 2800 | 28240 |
| 14 | Same as plot 9 | 5180 | 5610 | 6390 | 6651 | 4900 | 28731 |
| 15 | Nothing | 5360 | 5450 | 5855 | 3500 | 3200 | 23365 |
| 16 | Same as plot 11 | 5960 | 5570 | 5710 | 5498 | 3700 | 26438 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | Same as plot 12. | 6075 | 5110 | 5425 | 4546 | 3950 | 25106 |
| | RYE SEEDED ON CORN GROUND. | | | | | | |
| 18 | Same as plot 8 | 5820 | 5010 | 5665 | 6050 | 4300 | 26845 |
| 19 | Same as plot 9 | 6250 | 5490 | 6100 | 6196 | 3300 | 27336 |
| 20 | Nothing | 6400 | 4910 | 5060 | 4701 | 4000 | 25071 |
| 21 | Same as plot 11. | 5645 | 4820 | 4925 | 5199 | 4550 | 25139 |
| 22 | Same as plot 12. | 6105 | 3640 | 5210 | 4646 | 3450 | 23051 |

TABLE XIII.

*Showing Summary of Yields with Different Forms of Phosphoric Acid.*

(In pounds per Acre.)

| | 3 Corn Crops | | Wheat. | | | Total product 5 crops | | |
|---|---|---|---|---|---|---|---|---|
| | Grain Lbs. | Fodder Lbs. | Grain Lbs. | Straw Lbs. | Hay Lbs. | Grain Lbs. | Fodder Lbs. | Total Lbs. |
| Average of 4 nothing plots: (5, 10, 15, 20) ........... ...... | 9203 | 7387 | 1309 | 2601 | 3862 | 10512 | 13850 | 24362 |
| Average of 3 soluble phosphoric acid plots, (1, 2, 3) | 9095 | 7453 | 2203 | 3815 | 4350 | 11298 | 15618 | 26916 |
| Average of 2 reverted phosphoric acid plots, (4, 6)... | 9590 | 8035 | 1936 | 3360 | 4525 | 11526 | 15920 | 27446 |
| Average of 5 insoluble phosphoric acid plots, crimson clover turned under, (7, 8, 9, 11, 12)...................... | 10073 | 7610 | 1864 | 3837 | 4020 | 11937 | 15467 | 27404 |
| Average of 4 insoluble phosphoric acid plots, crimson clover turned under, (8, 9, 11, 12)....................... | 10201 | 7620 | 1946 | 3942 | 4025 | 12147 | 15587 | 27734 |
| Average of 4 insoluble phosphoric acid plots; nothing turned under, (13, 14, 16, 17) | 9615 | 8033 | 2025 | 3611 | 3838 | 11640 | 15481 | 27121 |
| Average of 4 insoluble phosphoric acid plots, Rye turned under, (18.19, 21, 22) | 8850 | 7315 | 2012 | 3511 | 3900 | 10862 | 14726 | 25588 |
| Average of 12 insoluble phosphoric acid plots, (8. 9, 11, 12. 13, 14. 16, 17, 18, 19, 21, 22)...................... | 9555 | 7656 | 1994 | 3688 | 3921 | 11549 | 15265 | 26814 |
| Average of 3 Bone-meal plots, (8 13, 18 ............ | 10029 | 7907 | 2120 | 3903 | 3867 | 12149 | 14677 | 26826 |
| Average of 3 Slag phosphate plots, (9, 14, 19).... | 9625 | 7647 | 2160 | 4195 | 4217 | 11795 | 16059 | 27854 |
| Average of 3 S. C. rock plots. (11, 16, 21)........... | 9294 | 7593 | 1890 | 3508 | 4217 | 11184 | 15318 | 26502 |
| Average of 3 Florida soft phosphate plots, (12, 17, 22) | 9273 | 7477 | 1800 | 3147 | 4050 | 11073 | 14674 | 25747 |

## DISCUSSION OF RESULTS.

The matter of drawing conclusions from results obtained from plot experiments is always attended with more or less uncertainty, as soil and weather variations will often bring about what may seem to be contradictions. There are also, often uncontrollable and unnoticed errors produced by the depredations of birds, mice, insects &c. While these may be very small in themselves, yet when the error is multiplied to represent yields per acre, it may amount to considerable. In order to obviate some of these difficulties there has been no report made on the experiments under discussion until they have been through five years, and covered several kinds of crops. Ever a longer period than this would be desirable, as it would probably serve to confirm some conclusions and to eliminate some doubtful points. These tests will be continued for some years.

The quantities of phosphoric acid applied in these tests are rather more than was necessary and more than would be found economical in practice; but it was thought best in planning the experiments to have an excess present and so endeavor to make the results more pronounced, than to attempt to run on the basis of greatest profit. It was the principles of phosphoric acid fertilization that were desired to be established rather than the limits of the soil requirements.

*Nothing Plots*; (*Nos.* 5, 10, 15, 20). An examination of table 13 page 24, shows that the average total product from the plots receiving no fertilizer was considerable below the average yields of all the plots which were fertilized. With some crops there was little increase in the yield through fertilization, and in a few instances the *nothing* plots made a slightly higher yield than those fertilized. This is noticeably the case with corn. The unfertilized plots of corn made a better average yield than those receiving the soluble phosphoric acid with rye turned under. The failure of the phosphoric acid plots to outyield the *nothing* plots was probably due in a measure to the phosphate being very available to the plant, over-stimulated it in the start, and this produced a condition in the plant which made it not so able to withstand the period of drought later in the season and at a time when the grain was forming and there was greatest call for food and activity. This is borne out in a measure by a comparison of the detailed yields as given in table 8 with the rain-falls as given in table 9. There is also a probability that the soluble phosphoric acid, when it entered the soil, was precipitated and formed unions which were not available to the crops, but this condition would not likely produce a decrease in the yields. All of the fertilized plots made very decidedly larger yields of wheat than the *nothing* plots, which would seem to show that the feeding habit of wheat is very

different from corn and that it particularly benefitted by the addition of phosphoric acid.

*Soluble Phosphoric; Acid*; (*Nos.* 1, 2, 3:) The figures in table 13 show that all the other forms of phosphoric acid gave higher total yield in five years than the soluble phosphoric acid, except on the plots where rye was turned under. The slightly higher total yield in the case of the rye turned under is accounted for in the corn crops and is probably due to the rye decomposing slowly and causing the soil to dry out easily, have a poor physical condition and thus suffer from drought. Soluble phosphoric acid seems to be particularly beneficial to wheat where it gave the highest average yield. The probable failure of soluble phosphoric acid to give good yields on corn, has been discussed under the *nothing* plots.

A comparison of the different sources of soluble phosphoric acid, as shown by the figures in tables 8, 10 and 12, shows the total yield to stand in favor of the most concentrated fertilizer or in the order of the plot Nos. 1, 2, 3. The wheat yield was in favor of the dissolved bone-black and hay was best on the dissolved South Carolina rock plots. This was probably due to the action of the sulphate of lime in the dissolved goods, liberating and forming available combinations with the potash in the soil.

*Reverted Phosphoric Acid;* (*Nos.* 4 and 6:) Reverted phosphoric acid gave better total yields for the five crops and better average yields in corn and hay, than soluble phosphoric acid; though not quite so large a yield of wheat. This would seem to confirm the popular idea that reverted phosphoric acid has as great an agricultural value as soluble phosphoric acid. A comparison of reverted phosphate of lime and reverted phosphate of iron and alumina (table 12, plots 4 and 6 respectively) show in every instance with every crop to be in favor of the reverted phosphate of iron and alumina.

*Insoluble Phosphoric Acid;* (*Nos.* 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22:) An examination of table 13 shows the average yield of the five insoluble phosphoric acid plots (Nos. 7, 8, 9, 11, 12,) to have produced considerably more grain than either the soluble or reverted forms of phosphoric acid, but the amount of fodder was slightly in favor of both the latter. The total product (grain plus the fodder) was more on the insoluble than on the soluble phosphoric acid plots, and within 42 pounds as much as the reverted phosphoric acid. The value of these results is still further advanced when it is considered that the price per pound of the insoluble phosphoric acid was only about one-half as much as that obtained in the soluble and reverted forms. The above comparisons include only plots 1 to 12, as these were treated uniformly with respect to turning under crimson clover green.

A comparison of the different sources of insoluble phosphoric acid as given by the figures in table 13 page 24, shows slag phosphate to have produced the larger total yield (also a larger total yield of both grain and fodder) than either soluble or reverted phosphoric acid. Bone-meal produced a little more grain than any other form of insoluble phosphoric acid, but the cost per pound of plant-food was about 50 per cent more than that in the slag and three times as much as that in the South Carolina rock and Florida phosphates. The insoluble phosphate of lime as furnished by the South Carolina rock, gave better results than the insoluble phosphate of iron and alumina as furnished by the Florida soft phosphate.

*Green Crops for turning under with Insoluble Phosphates:* In order to test the value of green crops, or vegetable matter, for rendering insoluble phosphates available, four plots had crimson clover seeded in corn for turning under; four plots had rye seeded in the same manner while four others had no green crop turned under and were allowed to remain bare during the winter. These plots showed the average results to be considerably in favor of the crimson clover for this purpose. Part of the advantage of the clover, no doubt, existed in the nitrogen which it furnished and also in the available plant-food which it brought from the subsoil. The clover decomposes rapidly and aids the physical condition of the soil. The rye used seems to have been a disadvantage and did not give as good yields as when no green crop was used. This was particularly the case with the corn crop. The disadvantage rested, probably, in the rye decomposing slowly and thus producing a bad physical state at times and making the corn crop suffer from dry weather.

There is one fact worthy of note, though not directly concerning the experiment under discussion, and that is that by turning under a large amount of a leguminous crop like crimson clover, corn can be successfully grown for a number of years in succession with increasing yields. Compare the average yields of plots 5 and 10 with those of plot 15 in table 8 page 18.

## CONCLUSIONS.

In the matter of drawing conclusions it is always well to be cautious and to err, if at all, on the side of conservatism. This policy is particularly well adapted with reference to the application of the results which have been obtained in the experiments under consideration and in using the conclusións that may be drawn.

There is no doubt that the results obtained, as shown by the total product of the crops for five years (last column table 13 page 24,) are at variance with the principles commonly taught and practice generally

followed in the matter of fertilization. With these considerations it would be well for those persons who desire to apply these results or use any different source or form of phosphoric acid from that which has been successfully and satisfactorily used in the past, to do so on a limited scale in order to be satisfied that these results will hold under the new and different conditions which may surround each particular case.

The average total results as given by the figures in table 13 page 24, show that insoluble phosphoric acid, that is phosphates which *have not* been treated or dissolved in sulphuric acid (Oil of Vitriol) have more pounds of crop, both straw and marketable grain, than the phosphoric acid in the soluble and reverted forms; that is in phosphates which have been dissolved in sulphuric acid. Not only has the yield produced by the insoluble phosphoric acid been greater than that produced by the soluble phosphoric acid, but the cost has been only about one-half as much. On this point particular attention is directed to plots 3 and 11, tables 8 and 12 which show the results obtained with the dissolved and undissolved South Carolina rock; the standard and base for most fertilizers.

The results obtained show that crops are able to use the insoluble phosphoric of South Carolina rock, notwithstanding the preaching and contention of most fertilizer manufacturers.

The results show that slag phosphate (which is mostly a tetra-phosphate of lime, classed by some as available to crops, yet classed by the American Official Methods of Analysis as mostly insoluble phosphoric acid), gives a greater total yield than any of the other insoluble phosphates. The yield of corn (grain) though not quite as much with slag phosphate as with bone-meal, yet was greater with wheat and grass. All yields were produced at less cost with slag phosphates than with bone meal.

Bone-meal was the best form of insoluble phosphate for corn, but its accumulative and supposed lasting effects did not show on the wheat and grass.

Bone-meal has also had an advantage over the other phosphates in furnishing some nitrogen.

The results obtained show crimson clover to be the best crop to use for obtaining organic matter in the soil in order to procure the best results with the insoluble phosphates.

# SUMMARY OF PRINCIPAL RESULTS.

1. All forms of phosphoric acid produced an increase of crop.

2. The average total yield of the crops fertilized with insoluble phosphoric acid was greater than those with the soluble and reverted forms of phosphoric acid.

3. Reverted phosphoric acid gave a greater total yield than soluble phosphoric acid.

4. Reverted phosphate of iron and alumina gave a higher yield than reverted phosphate of lime.

5. Soluble phosphoric acid gave slightly higher yields of wheat (grain) than phosphoric acid in any other form.

6. Concentrated sources of soluble phosphoric acid gave better results than the low grade sources.

7. Untreated S. C. rock gave a higher total yield than dissolved South Carolina rock.

8. Slag phosphate produced a greater total yield and at less cost than the average of the soluble phosphoric acid plots and the bone meal plots.

9. Insoluble phosphoric acid from slag, produced a greater yield than the insoluble phosphoric acid from S. C. rock and Florida soft phosphate, but at greater cost than the two latter.

10. For the best results with insoluble phosphates, it is desirable to have the land well filled with organic matter. Of the methods tested,crimson clover was the best means of obtaining this.

# THE MARYLAND
# AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 69. October, 1900.

## THE INFLUENCE OF FEED AND CARE ON THE INDIVIDUALITY OF COWS.

BY C. F. DOANE, M. S. AG. DAIRY BACTERIOLOGIST AND ASST. DAIRYMAN.

In discussing the record of a dairy herd with the object of showing the effect of good feed and care on the dairy temperament and the productive capacity of each separate cow of the herd, the results or improvements could be more satisfactorily shown if an exact history of each animal, as to her breeding, feeding, care, etc. could be given. Unfortunately in gathering together cows from the sources and for the object that the herd at this Station was collected, it is impossible to obtain the complete history of each individual. It is also true that it is almost impossible for experimental workers to know or determine just what data will be necessary or desirable in covering all possible results which may develop. As a consequence we have so meager an individual history of the cows of the Station herd and know so little of the condition of care and feed under which each cow was kept prior to coming to the Station, that only general conditions existing in the sections from which the cows were purchased can be given and used as a basis in the discussion.

The Station herd was selected so as to have it represent as nearly as possible the average dairy herd found in this State; so that the results obtained from experiments which were to be conducted in feeding, breeding and creamery, would be representative and have application to average conditions as found on dairy farms. For this reason in purchasing the cows of the Station herd no effort was made to obtain individuals of more than ordinary merit for dairy purposes. Average cows from average herds were selected and in a few instances the cows were below the average. The result was that the Station herd as a herd was no better than the average herd of dairy cows found in any average community of this State, giving their attention to this industry. Grade Holstein, Jerseys, Shorthorns and Herefords, and cows without the characteristic markings of any particular breed made up the number in about the proportion that the grades of such breeds are found in the dairy districts of the State. A few pedigreed cows of the Jersey and Guernsey breeds were purchased to give the Station representatives of those breeds, but their records are not considered in connection with this bulletin.

The section from which most of the cows of the herd were obtained is a thriving agricultural community practicing more advanced methods

than those followed on the average farm in Maryland. This section is situated near the City of Washington and practically all the milk produced goes to supply the milk and cream trade of that city. Few of the farmers are engaged exclusively in dairying, many of them devoting their land principally to grain and hay crops which are largely fed to fattening stock, the dairying being with many incidental. As stock feeders it is natural to find the so-called general purpose cow as a representative type. This accounts for the relatively small quantity of Jersey and Holstein blood found in the individuals of the herd. The cows of the section will produce an average amount of milk rich enough to meet the requirements of the Washington market. The common custom has been to have the calves dropped early in the spring, pasture the herd without grain or with very little grain and little or no provisions for a drought during the summer, and have the cows dry during all or a great part of the winter. Where grain is fed not much attention is paid to having the ration properly balanced, and corn being the cheapest forms the principal part of the grain ration.

Since the herd has been at the Station each cow has had the best of care, feed and surroundings. A good yard has been provided in summer into which the cows were turned every fair, cool day and every night during the summer, also days in the winter which were not wet and cold. In bad weather in winter they were turned out just long enough to drink water which was many degrees above the freezing point. The stable used is well lighted and ventilated, and at the same time warm, the temperature rarely going to the freezing point. Each cow was carefully groomed every morning and the stable was kept thoroughly clean, the space behind the cows being scrubbed every other day, the stable having a cement floor. Plenty of good bedding was supplied during the winter while the cows were confined principally to the stalls. Because of the garlic and the limited area of land which the Station could devote to pasturage, the cows have always been soiled during the summer. Rye was sown in the fall and made an early green food. This was followed by crimson clover and crimson clover was followed by other grasses, and these in turn by green corn which was fed until frost came. During the winter some mixed timothy and clover hay was fed for roughage, but the main dependence was placed on corn stover which was cut and fed dry. Grain has been given both summer and winter to cows during lactation. The amount fed has varied with the cow and the amount of milk being given, but no attempt has ever been made to force any cow in the herd. Twelve pounds of grain has been the maximum ration fed to cows giving a full flow of milk in the winter while on dry feed. The amount has been less to cows receiving green feed in the summer. During the winter of 1899 and 1900 a portion of the herd received ensilage and only half the usual amount of grain was fed to the cows receiving it. In considering how much grain should be fed each cow it has always been the desire to keep the animal in good dairy condition, or carrying sufficient flesh to give the most milk. With us this means that the cow would be poorer than many dairymen would advise. As can be seen from the accompanying illustrations of the cows considered in the bulletin a few have a little more flesh than is necessary, but with the exception of number 10 and

number 28 which naturally carry considerable flesh the extra fat is due to the cows having had the run of a woodland pasture along with all the green feed they would eat. They gained in flesh before the grain ration was adjusted to the new conditions. The character of the grain ration has varied as the cows of the herd have been under different feeding experiments. The main dependence has been placed on corn and cob meal, hominy chop, bran, gluten meal, and occasionally a little linseed meal or cotton seed meal. These, of course, have not all been fed at the same time, but selections have been made from these in the right proportion to make a properly balanced ration when fed with the coarse fodders used. A very narrow ration was fed for a time to a part of the herd, and a grain feed composed exclusively of hominy chop was given to a few of the cows at another time. The hominy chop, when fed alone, made such a material difference in the amount of milk given by the cows which received the ration, that it will be noted in studying the individual records of the animals considered in this bulletin. The fact that a certain fixed ration was not fed to all the cows all of the time detracts somewhat from the value of the results, but if it has caused variation the records have been lowered from what it would have been possible for the cows to have done. This is particularly so in the case of the cows that were fed exclusively on hominy chop which like corn meal is a very fattening food. The cows which received this hominy chop gave much less milk excepting for the first two months of the lactation period, did not give milk through as long a period, and gained more flesh than the cows given a well balanced ration. It is also likely that this ration of hominy chop injured the future dairy possibilities of the cows to which it was fed, as these cows went back in their milk yield instead of making any dairy growth during the time which it was fed.

Very little work in trying to improve individual cows by systematic care and feeding through a number of years has ever been done. At least there is no record of such work being carried on at our Experiment Stations. The attempt has always been to secure improved progeny by introducing the blood of some of the well known dairy breeds. Herds of dairy cows belonging to the Experiment Stations have not as a rule, if in any case, been collected for the same purpose as the herd belonging to this Station. A number of herds have been collected from the grade and native stock of the respective states but the buying has actually been done by an expert judge of dairy cows who has selected as far as possible the best animals from the best herds. After the herds were purchased the poor cows were given no chance to develop under their new conditions. The first year's record has been taken as evidence of the cow's ability and those which failed to make satisfactory records have been weeded out. As was said before the herd at this Station was not selected with the object of getting the best, and in but one instance was a cow sold because of her poor dairy qualities. Cow No. 4 of the herd was disposed of after being with the herd for three years. She was so far below the average in quality that we took it for granted that any farmer, no matter how short sighted, would realize that she was being kept at a loss, and would have disposed of her at the first opportunity as she was fat enough for beef even when on pasture.

The Cornell Experiment Station of New York has carried out a few yearly experiments in feeding grain to cows on green pasture in comparison with cows receiving no other food than that afforded by the pasture. The results of these experiments, three in number, which were all planned along the same line were published in bulletins 13, 22 and 36 of that station. In the first of these experiments which is considered in bulletin 13 there was no perceptible increase in the flow of milk of the grain-fed cows over the amount given by the cows pastured exclusively. In the second experiment considered in bulletin No. 22 the same general result was obtained as in the first experiment. But in the third experiment which was carried simultaneously with the herd belonging to the Station and with a herd belonging to a farmer of the State, the increased milk and butter received from the grain fed cows was more than sufficient to pay for the grain eaten. This did not take into consideration the increased value of the manure from the grain-fed cows which must have been considerable, or equal to a large per cent. of the first cost of the grain. Neither did it take into consideration the saving in the pasture which amounted to something. But now comes the result which bears more directly on the subject considered in this bulletin. In choosing a herd outside of the Station to be experimented with in conjunction with the Station herd, one was selected which had never received grain during the summer and which was in comparatively poor condition. The next year after the experiment was conducted a record was kept of the milk produced by this herd though no grain was fed during the second year. The cows which had received grain the previous year gave over 16 per cent. more milk in six months than the lot which had received no grain. In commenting further on this second year's result Director I. P. Roberts of the Cornell Station says that it was evident that the two and three year olds of the herd which had received grain during the experiment, developed into much better animals than their stable-mates which had received no grain.

In considering the records of the cows belonging to this Station, the Statement made by Director Roberts, in reference to the improvement noticed in the young cows which had received grain, seems to be very much emphasized. Not only in young cows is this development noticed, but it also seems to be true of mature animals. And this development, which is not noticed during the first year which the cow receives grain is noticed in the second year and continues until, as was the case with the majority of the cows of the herd belonging to this Station mature but inferior and unprofitable dairy animals develop into very profitable cows for dairy purposes. This was true at the Cornell Station. No very material results could be noticed the first year from the extra feed and care the herd received, but through subsequent years there seems to be a steady improvement. Judging from the records of these cows it is a question if the quality of a dairy cow does not depend almost as much on the feeding as on the breeding. It is also a question if cows which have a more or less pronounced beef tendency, or at least would not be called good material from which to build up a dairy herd, cannot with proper management, be developed into profitable dairy cows. It seems that the change from no grain feed, or a grain ration composed largely of corn, to a liberal balanced ration, changes the entire nature of the cow to some extent. This

will be brought out to better advantage in the individual records of the herd.

In the following tables or yearly record of the cows the lactation period was calculated from the time the milk was fit to use, about seven days after calving, until the cow ceased to give milk. Where the cow gave milk for more than eleven months the lactation period was limited to eleven months. It would be manifestly unfair if a cow gave milk but six months one year to limit her following lactation periods to the same length of time, as persistency in milking is one of the qualities which must be considered in calculating the actual value of a cow for dairy purposes. It would also be unfair to allow more than eleven months as a cow ordinarily drops a calf every year, and it is a common practice or should be, to allow her a few weeks of rest by drying her off at least a month before calving.

In giving the following yearly records of the cows the points which are necessary in demonstrating the improvement of the herd, along with a few things which may be of interest to the reader, are given. In calculating the weight in good dairy condition the weight is given at which that particular animal should be kept to give the most milk. With some cows this means a little more fat than with others, depending on the nature of the particular cow. The Station herd originally contained fifteen native and grade cows. The records of ten are considered in this bulletin, the others died or were sold because of abortive tendencies before they had been at the Station a sufficient length of time to make their records of any value in this connection. The cows of the herd are known by number, a consecutive number being given to each cow as she is purchased or to the heifers as they are born. The numbers are given as they appear in the Station Herd Book. No. 28 and No. 29 were purchased after some of the other cows had given birth to heifer calves, and also after the purchase and numbering of some pedigreed cows. This accounts for their coming so far down in the numerical order. This is mentioned to prevent any suspicion that animals which had not improved had been excluded. The record of every native or grade cow owned by the Station for two or more years is given with one exception. In this case the cow aborted twice within such a short period that no comparison of her record could be made.

The records are given along with a few explanatory notes and the pertinent history as far as it can be given. It is to be regretted that illustrations of all the cows considered can not be given, but we do not happen to have photographs of cows not now owned by the Station.

RECORD OF COW NO. 1.

| | Feb. 17, 1896 Jan. 17, 1897 | July 19, 1897 Feb 15, 1898 | June 2, 1898 May 2, 1899 | Sept. 26, 1899 Aug. 26, 1900 |
|---|---|---|---|---|
| Total milk lbs. | 4004 | 3187 | 1685 | 6092 |
| Average test, | 5.5 per ct. | 4.8 per ct. | 4.9 per ct | 5.2 per ct |
| Highest test, | 6 5 " | 6.4 " | 6.0 " | 5.9 " |
| Lowest test, | 3.0 " | 4.0 " | 3 8 " | 4.1 " |
| Total butter lbs., | 258.3 | 177.0 | 303 2 | 370.0 |
| Highest monthly yield of butter, lbs., | 27.7 | 34.0 | 38 5 | 40 3 |
| | Weight when purchased, 747 lbs. | | | |
| | Weight in good dairy condition, 915 lbs. | | | |

## HISTORY OF COW NO. 1.

Cow No. 1 gave birth to her second calf shortly after coming to the Station in the early winter of 1896 and as far as could be determined was about three years old. She is a high grade Jersey and shows her Jersey blood to a marked degree in her color and in her relatively high tests. The accompanying illustration of No. 1 shows her to have a little more flesh than is necessary which is temporary however as she is not a cow with any pronounced beefy tendencies. Her udder is not well shaped but is of fairly good size and she has good milk veins. When in full flow of milk her udder comes well up behind, showing to much better advantage than the illustration would lead one to believe. Her photograph as well as others reproduced was taken near the end of the lactation period. Though she has made good records during her last two lactation periods she would hardly, judging from appearances, be called an extra good dairy animal. It is reasonable to believe that her good record is due more to the feed and care she has received than to any inherent dairy qualities. In studying her records for the four years it is seen that, while she did well in her first lactation period and showed herself to be a persistent milker, she made a very poor record during her second lactation period. In the second lactation period she fell off 817 pounds in milk yield .7 per cent. in her average test, and 81.3 pounds in the calculated yield of butter from her record for the first period of lactation. From August 1, 1897 to Feb. 1, 1898, which practically covers her second lactation period, she received a grain ration composed entirely of hominy chop which was fed in an experiment comparing this feed with a well balanced ration which the herd was receiving. From the records of that experiment there can be no doubt that the poor record made during the second lactation period, was due to the grain ration she received. This is emphasized in comparing the record of the second lactation period with the records made by her during the two following periods. How much if any effect the year's feeding on hominy chop had on the record of the following lactation periods is open to speculation, but it is certainly reasonable to believe that the cow would have made a better showing in the last two years had she received a balanced ration during the second lactation period. Her natural development would then not have been checked. Her record shows her to have given 2095 pounds more milk and to have made 111.7 pounds more butter the last lactation period than the first, and she also made much the best monthly record during the last lactation period. As cow No. 1

COW NO. 1 (FROM PHOTOGRAPH).

came to the Station before she was fully matured it is impossible to even estimate how much of her development was due to the good feed she received and how much was due to increasing age and greater maturity. The record of the second period of lactation however gives some hint as to what she would have done under the ordinary hap-hazzard feeding practiced by many dairymen.

RECORD OF COW NO 2.

| | Mch. 7, 1896 Feb. 7, 1897 | Nov. 1, 1897 July 20, 1898 | July 27, 1898 June 27,1899 | Sept. 9, 1899 Aug. 9, 1900 |
|---|---|---|---|---|
| Total milk in lbs. | 3461 | 4729 | 4157 | 3980 |
| Average test | 4 7 per ct. | 4.9 per ct. | 5 0 per ct | 5.1 per ct. |
| Highest test, | 6.0 " | 5.6 " | 5 4 " | 5.8 " |
| Lowest test, | 3.2 " | 4.2 " | 4.3 " | 4.7 " |
| Total butter lbs. | 190.3 | 269.9 | 242.7 " | 235.4 |
| Highest monthly yield of butter, | 23.2 | 40.4 | 33.8 | 33.2 |

Weight when purchased, 740 lbs.
Weight in good dairy condition, 1025 lbs.

## HISTORY OF COW NO. 2.

Cow No. 2 like Cow No. 1 came to the Station shortly before giving birth to her second calf and was purchased at the same time as No. 1. The first yearly record being that of the lactation period following the birth of the second calf. She was about three years of age as nearly as could be judged. She is a high grade Jersey of about the same breeding as Cow No. 1, both cows having been purchased from the same farm. She has the coloring and other characteristics of the Jersey breed. The accompanying illustration shows her to be a little too fleshy, but she was fatter at the time the photograph was taken than she is ordinarily kept, though she is a little inclined to carry too much flesh. As can be seen by the illustration she has prominent milk veins, a fairly well developed udder and a good constitution; but aside from this she would not from external appearances be called a good example of the dairy cow. She tests high but does not give a large flow of milk even during the first months after calving. She is, however, a very persistent milker, her record showing her to have given milk every month during the five years she has been owned by the Station. No. 2 aborted in the latter part of July 1898 which makes her record incomplete for that year as it allows only ten months for the second lactation period. This calf came two months before time and there can be little doubt that it also had its effect on the amount of milk and butter given during the lactation period following abortion, as it is very doubtful if a cow will give as large a flow of milk following an abortion at seven months as when she runs her full time. The records show No. 2 to have made but 190.3 pounds of butter during her first period of lactation. In the second lactation period she made 269.9 pounds of butter, an increase of 79.6 pounds over the record for the previous period. The yields of milk and butter for the two following periods of lactation show a decrease from the second lactation period, but there is no explanation that can be offered for this decrease. The increase in the second lactation

period over the first lactation period may have been due to the better feeding or it may have been due to greater maturity.

RECORD OF COW NO. 3.

| | Apr. 25, 1896 Mch. 15, 1897 | June 14, 1897 Feb 5, 1898 |
|---|---|---|
| Total milk, lbs | 4122 | 5051 |
| Average test, | 3.4 per ct. | 3.5 per ct. |
| Highest test | 4.4 " | 4.5 " |
| Lowest test | 2.5 " | 3.2 " |
| Total butter, lbs | 155.6 | 208.9 |
| Highest monthly yield of butter | 21.0 | 33.9 |

Weight when purchased, 850.
Weight in good dairy condition, 900 lbs.

## HISTORY OF COW NO 3.

The Station has no photograph of No. 3 as she developed tuberculosis in the early part of 1898 and was ordered killed by the Station Veterinarian. She was a grade Jersey coming from the same farm as No. 1 and No. 2 and was about the same general breeding as those two cows. But she was an entirely different type of cow from the other two, was much inclined to lay on flesh instead of giving milk and her record shows her not to have been so good a dairy cow as either of the other two. She came to the Station when about five years of age, or at an age that is ordinarily considered the prime of life for dairy cows. Her record for the two years she was owned by this Station shows a great improvement in her second period of lactation though the record for this last year is incomplete as she was killed less than eight months after calving. When killed she was giving a comparatively good flow of milk. The records show her to have been naturally a persistent milker, and had she lived to complete the eleven months it is likely that her butter yield for that year would have been at least 250 pounds instead of the 209 pounds given in the record, which was the actual amount made by the cow during the eight months of the lactation period. Comparing the records of the two periods of lactation it will be seen that she gave 829 pounds more milk and 53.3 pounds more butter in the second period of lactation than in the first. Her highest monthly butter yield increased from 21 pounds the first lactation period to 33.9 pounds the second lactation period. As the cow was fully developed when she came to the Station it is reasonable to give the improvement in feed and care the credit for the increase in the milk and butter. It is unfortunate that this cow did not live as she gave promise judging from the increase made in the two years of developing into one of the best cows of the herd. The development of the second lactation period is worth considering as had the cow lived it would have been almost 100 pounds and possibly greater than this amount. Comparing the milk and butter yield for the eight months recorded in the second lactation period with the first eight months of the first lactation period shows the improvement of the cow to better advantage. As shown by the table she gave 5051 pounds of milk in eight months in the second lactation period and made 208.9 pounds of butter. In the first eight months of the first lactation

COW NO. 2 (FROM PHOTOGRAPH).

period she gave 3405 ponnds of milk which made 134 pounds of bntter. She gained 1646 ponnds of milk and 74.9 pounds of butter.

RECORD OF COW NO. 4.

| | Sept. 25 1896 July 31, 1897 | Dec. 5, 1897 June 1, 1898 | Oct. 15, 1898 Sept. 15, 1899 |
|---|---|---|---|
| Total milk in lbs. | 5192 | 3757 | 6163 |
| Average test | 3.5 per ct. | 3.6 per ct. | 3.6 per ct. |
| Highest test | 4.2 " | 4.2 " | 4.0 |
| Lowest test | 2.7 " | 3.4 " | 3 4 " |
| Total butter; lbs | 215.4 | 160.0 | 257.1 |
| Highest monthly yield of butter | 27.4 | 40.0 | 27.2 |

Weight when purchased, 967 lbs.
Weight in good dairy condition, 975 lbs.

## HISTORY OF COW NO. 4.

Cow No. 4 like No. 3 left the Station before the herd was photographed and we have no illustration to use in conneetion with this bnlletin. She came to the Station when about six years of age and the first record given is for the laetation period following her fourth calf. No. 4 was a high grade Shorthorn of a large and beefy type and would have made an excellent cow for a herd where beef and not milk was the prineipal eonsideration. She was a square bnilt, large bodied cow and took on flesh very readily, and her dairy qualities were such as are often seen in cows of that type. She gave a large flow of low-testing milk for the first two or three months after calving, but she was not a persistent milker and the milk flow dropped off rapidly after the second or third month. In her second lactation period after coming to the Station she gave milk bnt six months though she gave over 1000 pounds of milk and made over 40 ponnds of butter the first thirty days of the period she was milked. No. 4 was pnrchased in the fall of 1895 and was giving a good flow of milk for her at the time. The first record given is for the lactation period following her first calf born at the Station which was dropped nearly a year after she was purchased. During the time she was owned by the Station and before she dropped this calf she received good feed. This acconnts somewhat no donbt for the relatively good record made during the first lactation period recorded. In that time she gave 5192 pounds of milk testing 3.5 per cent. which wonld give a calculated yield of butter of 215.4 pounds. This was 1445 pounds more milk and 55.4 pounds more bntter than she gave during her next lactation period. But in the third and last period of lactation recorded she gave 971 pounds more milk than during the first period of lactation and made 41.7 pounds more bntter. This variation of yield in the three lactation periods makes her record a little unreliable. It is likely however that her yearly reeords were influenced more or less by the time at which she was bred. The herd book shows her to have been bred Feb. 20th 1897 which was five months after the previous calf was dropped. She was bred the next time December 29th, 1897 which was only one month after dropping the second ealf. She was not bred in 1898 or 1899 and her milk flow for that laetation period continned more than the eleven months allowed. The period between the time when her milk flow ceased and when

the following calf was dropped was about four months in all three of the years she was owned by the Station. Her best monthly record was made during the second period of lactation, at which time she made forty pounds of butter. The next best monthly record was 27.4 pounds of butter, made during the first lactation period recorded. Great variation in yearly results of individual cows is often seen and many times it is impossible to offer a satisfactory explanation.

RECORD OF COW NO. 7.

| | Jan. 1, 1896 Dec. 1 1897 | June 21, 1897 Mch 30, 1898 | May 1 1898 Apr. 1. 1899 | June 1, 1899 May 1, 1900 |
|---|---|---|---|---|
| Total milk, lbs | 4537 | 4983 | 6134 | 5565 |
| Average test | 4.9 per ct. | 4.6 per ct. | 5 0 per ct | 5.5 per ct. |
| Highest test | 5 9 " | 6 0 " | 5.8 " | 6.3 " |
| Lowest test | 4.0 " | 3.6 " | 4.2 " | 4.8 " |
| Total butter, lbs | 258.8 | 269.0 | 357.0 | 362.2 |
| Highest monthly yield of butter | 27.8 | 36.4 | 48.0 | 38.4 |

Weight when purchased, 665 lbs.
Weight in good dairy condition, 925 lbs.

## HISTORY OF COW NO. 7.

No. 7 came to the Station when between four and five years of age, the first record given being for the lactation period following her third calf. She is a high grade Jersey, showing her Jersey blood very strongly in color, a very high test, and in her general appearance. The illustration shows this cow to be a good type of the dairy cow. She has a well developed udder, good milk veins and a good digestive capacity; and though she has a good sized frame she carries no extra flesh. It is in fact impossible to make her fleshy while giving milk. She cannot be forced in her milk yield and she cannot be over fed as she eats just sufficient grain to keep her in good flow of milk. Her weight when in good dairy condition is about 950 pounds and though nothing of her previous history is known, some idea of the care she must have had previous to coming to the Station can be gained, by comparing her weight at that time with her present weight. No. 7 is not a heavy milker, her best yearly record being 6134 pounds of milk, but she is a persistent milker and the milk tests exceptionally high. She aborted May 27, 1899, four months before she was due to drop her calf and there can be very little doubt that her milk and butter yield for the lactation period following the abortion is much less than it would have been had she dropped her calf at the proper time. Her best monthly record for this last period of lactation recorded was but 38.4 pounds of butter, while the best monthly record for the previous year was 48 pounds. The second period of lactation given in the record was cut short by the cow being bred on July 17, 1897, just one month after she had dropped her previous calf. This allowed but nine months in that period of lactation, two months less than the time allowed. Her record shows her to have increased every year but the last, in the amount of milk given, while there was an increase in her yield of butter every lactation period recorded. She gave but 4537 pounds of milk the first lactation

COW NO. 7 (FROM PHOTOGRAPH).

period, while during the third lactation period she gave 6134 pounds, an increase of 1597 pounds. Her increased butter yield is more marked as she made 362.2 pounds the last lactation period and only made 258.8 pounds the first lactation period, an increase of 103.4 pounds in the three lactation periods recorded. This greater comparative increase in butter over the increase in milk was due to the greater average test as the cow had an average test of but 4.9 per cent. the first lactation period and an average test of 5.5 per cent. the last lactation period recorded. Judging from the weight of No. 7 when she came to the Station it is very doubtful if she ever would have developed sufficiently to give enough milk to pay for even the small amount of feed consumed had she remained under the same management. She is one of these dainty, nervous cows which demand particularly good care but which, when they are rightfully treated, pay well for the extra trouble. The entire increase in the yield of milk and butter during the last three lactation periods as well as a large part of the yield during the first lactation period recorded, is more than likely due to the good feed and care she received while under the Station management. With poor treatment such cows nearly always go backward instead of forward.

RECORD OF COW NO. 9.

| | Feb. 1, 1896 Dec. 31, 1896 | June 5, 1897 Feb 28, 1898 |
|---|---|---|
| Total milk; lbs | 5114 | 4983 |
| Average test | 4 5 per ct. | 3.9 per ct. |
| Highest test | 6.4 " | 5.0 " |
| Lowest test | 3.0 " | 3 2 " |
| Total butter; lbs | 267 1 | 230 6 |
| Highest monthly yield of butter | 32.9 | 42.8 |

Weight when purchased, 820 lbs.
Weight in good dairy condition, 875 lbs.

## HISTORY OF COW NO. 9.

No. 9 gave birth to her fifth calf shortly after coming to the Station and the first record given is for the lactation period following. She was about seven years of age. As is generally calculated she was in her prime if not a little past the prime of her dairy abilities. She was a good sized cow having a very little Jersey blood. This did not show, however, either in color or form, the cow resembling the Shorthorn breed more than any of the dairy breeds. She was not a heavy milker, but she was a persistent one. She was not owned by the Station a sufficient length of time under the circumstances to judge what she might have done had she remained a number of years. Yet she made the best record for the first year of any cow owned by the Station with the exception of cow No. 28. No. 9 developed tuberculosis in the fall of 1898 and was slaughtered. This accounts for having the record of but two lactation periods and also for having no illustration. She was the only cow in the herd which did not make a yearly increase in her milk and butter yield while owned by the Station. She gave 5114 pounds of milk the first lactation period recorded and gave but 4983 pounds the second lactation period. Her average test fell from 4.5 per cent. in the first lactation period to an average test of

3.9 per cent. in the second. This makes an even greater relative difference in the yield of butter than in the yield of milk for the two lactation periods. It will be noticed however that she made by far the best monthly record in the second recorded lactation period. Her yield of butter for the first three months of the second lactation period was 111 pounds while for the first three months of the first lactation period recorded she made but 82 pounds. The record of the second recorded lactation period was shortened by the cow being bred less than a month after dropping her second calf at the Station. No. 9 was one of the cows which received a grain ration composed exclusively of hominy chop from August 1, 1897 to the end of her lactation period. She commenced to fall off rapidly in her milk yield shortly after commencing to feed the hominy chop, and her poor record for the year is undoubtedly due to the poor quality of this feed for the production of milk. This may also be the reason her average test for the second lactation period was lower than for the first period. The fact that we are very certain that the poor record made by this cow in her second lactation period was due to the grain ration which she received would justify her being dropped from consideration in this bulletin. Her record cannot but detract from the force of the records of the other cows even with readers who know something of the poor qualities of hominy chop as an exclusive grain ration for dairy cows. But it was decided to give her record along with the accompanying facts and allow the reader to form his own conclusions.

RECORD OF COW NO 10.

| | Mch. 1, 1896 Feb. 1, 1897 | Nov 1, 1897 Oct. 1, 1898 | Sept. 24, 1899 Aug. 24. 1900 |
|---|---|---|---|
| Total milk; lbs. | 6097 | 6995 | 6683 |
| Average test | 3.7 per ct. | 3.9 per ct. | 4 5 per ct. |
| Highest test | 4.2 " | 4 3 " | 4.8 " |
| Lowest test | 2 0 " | 3.0 " | 4.2 " |
| Total butter; lbs | 263.0 | 315 0 | 348.3 |
| Highest monthly yield of butter | 31.3 | 35.3 | 35.0 |

Weight when purchased, 760.
Weight in good dairy condition, 875 lbs.

## HISTORY OF COW NO. 10.

No. 10 came to the Station when about five years of age and she appeared to be fully developed. The accompanying illustration is an excellent representation of her as she appears when in the best condition for giving a good flow of milk. She is a dark brindle cow showing none of the characteristic markings either in color or form of any of the dairy breeds. Leaving her color out of consideration she would make a pretty fair representative of the Cruikshank Shorthorns which are a typical beef breed. She is short legged, and square bodied except for a rather large abdominal capacity and she is always fat, or always has been fat since her first year at the Station. About the only visible thing about her which would suggest any dairy qualities is the large abdomen before alluded to, which is usually taken as a sign of good digestive capacity. She also has a fairly well developed udder and milk veins which however do not show

COW NO. 10 (FROM PHOTOGRAPH).

in the illustration. She is a prepotent breeder as her calves, even when she is bred to the best bulls, have the characteristic color and square body of the dam. No. 10 is a persistent milker, and though she has made no large monthly record her yearly records have been good. Her persistency as a milker is shown to good advantage in the length of time she gave milk following the birth of the second calf dropped at the Station. This calf was dropped Oct. 24, 1897. In the year ending Dec. 31, 1898 she gave 6668 pounds of milk which made 312 pounds of butter. In the month of January 1899 she made 22.6 pounds of butter, this being the fifteenth month of her lactation period. No. 10 shows an increase in her yield of butter every succeeding lactation period since she has been in the Station herd. She made 52 more pounds of butter the second lactation period than the first and made 85.3 more pounds the third lactation period than the first. She gave 898 more pounds of milk the second lactation period than the first, but dropped off to 586 more pounds the third lactation period. Her average test was .6 higher the third lactation period than the second which accounts for her greater yield of butter. As No. 10 was in the prime of life when she was purchased the increase in her butter yield since then must have been due to the better feed and care.

RECORD OF COW NO 15.

| | Sept. 1, 1896 May 15, 1897 | Nov 5, 1897 Aug 10.1898 | Sept. 10,1898 Aug 10,1899 | Nov. 9 1899 Aug. 1, 1900 |
|---|---|---|---|---|
| Total milk; lbs | 4035 | 6055 | 7995 | 6645 |
| Average test | 3.8 per ct | 4.0 per ct | 3 8 per ct. | 4 35 per ct. |
| Highest test | 4 5 " | 4 3 " | 4 7 " | 4 6 " |
| Lowest test | 3.5 " | 5.0 " | 3 0 " | 4.0 " |
| Total butter, lbs | 182.9 | 285 7 | 359.2 | 338 0 |
| Highest monthly yield of butter | 27.6 | 39.7 | 4[illegible].7 | 57.5 |

Weight when purchased, 855 lbs
Weight in good dairy condition, 1000 lbs.

### HISTORY OF COW NO. 15.

No. 15 was selected from a number of cows which were shipped to Washington D. C. from some western point. As a consequence even less is known of her previous history or the conditions under which she was raised than is known of the other cows of the herd. As nearly as could be determined she was about five years of age when coming to the Station and was to all appearances a fully developed cow. She is a grade Hereford; and for a grade she is a remarkably prepotent breeder. Her calves invariably have the same square form of the dam and usually have the characteristic color markings of the Hereford breed, even when bred to the most prepotent bull. The accompanying illustration shows No. 15 to be a large bodied cow with good digestive capacity and a good sized udder. When she was purchased by the Station she was shaped more like a beef animal having a very square body carrying considerable flesh. But she seems to have developed along dairy lines and she has lost the tendency to lay on flesh even when highly fed. Her calves when first dropped are very square built and have every appearance of developing into beef animals, though sired by Jersey bulls. No. 15 is a heavy milker and has been a

rather persistent milker, giving a good flow of milk for ten months in the year. She has proven to be the best cow in the herd and shows exceptional dairy qualitics for a cow having so much Hereford blood as her calves would lead one to believe she has.

The record of No. 15 for the first year is not complete. She responded to the tuberculine test in May 1897 and was removed to a neighboring farm. She remained at that farm until after the next calf was dropped, when, not responding to another tuberculine test, she was returned to the Station herd. As she made but 17.5 pounds of butter in the month of April 1897 it is likely that her milking period for that year was about completed, and it is doubtful had she remained at the Station if she would have made sufficient butter to have brought her record to 200 pounds for the entire lactation period. As she was not returned to the Station until three weeks after entering on the second lactation period recorded it would be no more than fair to add 20 pounds to her record of 285.7 pounds of butter for that period. No. 15 aborted the first of August 1900 which shortened her lactation period for that year. Her monthly record of that last lactation period given shows some unexpected peculiarities. She made her best monthly record in the last lactation period and also fell off in her monthly yields of milk more rapidly. It may have been possible that the same disturbance or condition which led to her abortion caused her milk yield to drop off rapidly. No. 15 showed a material increase in her milk and butter yield the first three lactation periods she was owned by the Station. During the last lactation period recorded, though her total yield fell off greatly, she shows a superiority over other lactation periods in a monthly record of over 15 pounds more butter than in any month of any previous lactation period. In the second lactation period she made about 102.8 pounds more butter than in the first lactation period. In the third lactation period she gained 73.5 pounds of butter over the second lactation period, a total gain of 176.4 pounds of butter in the two years. A great part of this gain is certainly due to development under better care and feed.

## RECORD OF COW NO. 28.

| | Oct. 12, 1897 Aug 10, 1898 | Sept. 1, 1898 July 15, 1899 | July 25, 1899 June 25, 1900 |
|---|---|---|---|
| Total milk; lbs | 6357 | 6828 | 6653 |
| Average test | 3 9 per ct. | 3.8 per ct. | 4 1 per ct. |
| Highest test | 4.4 " | 4 4 " | 4 6 " |
| Lowest test | 3 6 " | 3 6 " | 3 6 " |
| Total butter; lbs | 293 4 | 297 0 | 315.9 |
| Highest monthly yield of butter | 38.2 | 33.8 | 33.7 |

Weight when purchased, 872 lbs.
Weight in good dairy condition, 1000 lbs.

## HISTORY OF COW NO. 28.

No. 28 is a grade Holstein and is the only cow in the herd having any blood of that breed. She was purchased in the fall of 1897 and was about five years old at the time. The accompanying illustration shows

COW NO. 15 (FROM PHOTOGRAPH).

her to be a large cow with an excessively large abdomen. She carries considerable flesh for a dairy cow of the Holstein breed, but she is a hearty eater and it seems to be necessary to keep her in good flesh to get the best returns of milk. She has a fair udder and good milk veins which do not show in the illustration because of a very shaggy growth of hair on the belly and around the udder. No. 28 is a comparatively heavy milker but tests low. She is a persistent milker and has given milk every month since she has been owned by the Station. She gave a good flow of milk up to September 1900 though she aborted in July 1899, two months before it was time for her to drop her calf, and it is likely, because of this abortion her milk and butter yield for the following period of lactation was materially lessened. No. 28 made a gain in her butter yield each consecutive period of lactation she was owned by the Station, but this gain was so small that it is impossible to give any credit to changed conditions. She made a comparatively high record the first year she was owned by the Station and it may be that her previous treatment was better than was received by the other cows of the herd. She also made her best monthly record during that first period of lactation. The records given show a gain of but 3.6 pounds of butter in the second lactation period and 18.9 pounds of butter in the third lactation period. It must be remembered that the third period of lactation followed an abortion.

RECORD OF COW NO. 29.

| | Oct 15, 1887 July 5, 1898 | Sept 5, 1898 June 10, 1899 | Aug. 12, 1899 June 30, 1900 |
|---|---|---|---|
| Total milk; lbs | 4653 | 3210 | 5465 |
| Average test | 4 9 per ct. | 4 6 per ct | 5 0 per ct. |
| Highest test | 5.6 " | 5.5 " | 5 8 " |
| Lowest test | 4.2 " | 3 6 " | 4.1 " |
| Total butter; lbs | 264 4 | 172.6 | 321 0 |
| Highest monthly yield of butter | 38 9 | 24 1 | 37 0 |

Weight when purchased, 860 lbs.
Weight in good dairy condition, 950 lbs.

## HISTORY OF COW NO. 29.

No. 29 resembles somewhat in her coloring the Ayrshire breed of Cattle, but she more nearly resembles the Shorthorn breed in her general form and very likely has considerable Shorthorn blood in her. She carries considerable flesh naturally but was fatter than necessary when photographed. The illustration shows her to have some very good daily characteristics. She has a good digestive capacity, a good udder coming well up behind and extending forward, and she also has for a native cow, very large and prominent milk veins. She was about five years of age at the time she was purchased by the Station and was fully developed. No. 29 is not a heavy milker and in comparison with the other cows of the herd is not a persistent milker as she gives milk less than ten months of the year. But her milk tests high and she has made some good monthly records. She aborted in August 1899 nearly two months before time to drop her calf. In the three years No. 29 has been owned by the Station she has improved very much as a dairy cow. This is shown in the records of her lactation

periods. In the third lactation period she gave 812 pounds more milk and made 116.8 pounds more butter than in the first lactation period. The record of her second lactation period shows her yield of milk and butter as well as her average test to be below the record of her first lactation period. There is no reason known why this should have been the case She started out with a very light monthly yield and never seemed to gain on her milk flow. It is well known by all owners of large dairy herds, especially where a daily and monthly record of each animal is kept, that individual cows, without any apparent reason, will fall some years far below their average yearly record. The next year they may entirely recover their dairy abilities as No. 29 did or in other instances they may he failures as dairy cows for all future time. Sometimes satisfactory explanation for this result can be given but many times there is not apparent reason. In this case the record of the second lactation period is so at variance with the records of the other lactation periods that it should not be considered in the general results, or in any way considered as evidence that cows will not improve with the conditions under which the Station herd is kept. The record of the last lactation period certainly shows that No. 29 made substantial improvements with the care and feed received at the Station.

| Cow N | Milk. Lbs. First lactation period given. | Highest yield of milk, lbs. any lactation period | Gain in milk, lbs | Average test first lactation period given Per cent. | Highest average test any lactation period. Per cent. | Gain in average test. Per cent. | Pounds of butter made first lactation period given. | Most butter made any lactation period. Lbs. | Gain in butter made. Lbs. | Highest monthly yield of butter any lactation period. Lbs. | Gain in monthly yield of butter. Lbs. | Number of lactation periods recorded. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4004 | 6091 | 2087 | 5.5 | 5.5 | .. | 258.3 | 370.0 | 111.7 | 40.3 | 12.6 | 4 |
| 2 | 3461 | 4729 | 1268 | 4 7 | 5 1 | .4 | 190.3 | 269.9 | 79 6 | 40.4 | 17.2 | 4 |
| 3 | 4122 | 5051 | 929 | 3.4 | 3.5 | .1 | 155.6 | 208.9 | 53.3 | 33.9 | 12.9 | 2 |
| 4 | 5192 | 6163 | 971 | 3.5 | 3.6 | .1 | 215.4 | 257.1 | 41.7 | 37.2 | 9.8 | 3 |
| 7 | 4537 | 6134 | 1597 | 4.9 | 5.5 | .6 | 258.8 | 362.2 | 103.4 | 48.0 | 20.2 | 4 |
| 9 | 5114 | 5114 | . | 4.5 | 4.5 | .. | 267.0 | 267.0 | ...... | 42.8 | 9.9 | 2 |
| 10 | 6097 | 6995 | 898 | 3.7 | 4.5 | .8 | 263.0 | 348.3 | 85.3 | 35.3 | 4.0 | 3 |
| 15 | 4035 | 7995 | 3960 | 3.8 | 4.3 | .5 | 182.9 | 359.2 | 176 3 | 57.5 | 29.9 | 4 |
| 28 | 6357 | 6828 | 471 | 3.9 | 4.1 | .2 | 293.4 | 315.9 | 22.5 | 38.2 | .. | 3 |
| 29 | 4653 | 5465 | 812 | 4.9 | 5.0 | .1 | 264.4 | 321.2 | 56.8 | 38.9 | . | 3 |

**Note —Cow No. 9 is the only one which fell in her butter yield. It will be remembered that during her second recorded lactation period she received an exclusive grain ration of hominy chop.**

The foregoing table shows that out of the ten cows considered in the bulletin all but one (No .9) made some gain in their milk and butter yields after the first lactation period they were owned by the Station. Of the nine

COW NO. 28 (FROM PHOTOGRAPH).

cows which did increase seven gained more than 50 pounds. Of the two which failed to increase their yield of butter, one (No. 3) made her gain of 41 pounds the second lactation period. She was owned by the Station only two years. All but two (Nos. 1 and 2) of the ten cows were mature animals when they were purchased by the Station and should have been at the height of their milk producing powers. They should have been doing as well as they ever could be expected to do with the same feeding and care they had been receiving. No. 1 and No. 2 might have done as well as they did had they remained in possession of their former owners, but cows under such management usually give about as much milk during the lactation period following their first calves as they ever do in any subsequent lactation period, and it is doubtful if No. 1 or No. 2 would have made such heavy gains. Of the ten cows considered in the bulletin No. 3, No. 4, No. 7, No. 10, No. 15 and No. 29 increased much more in their milk and butter yields than they could have possibly been expected to do had they remained under the same management they had been receiving prior to coming to the Station. They increased in their yields more than could be attributed to greater dairy powers due to increasing age and maturity.

Special attention is called to the fact that the cows considered in the bulletin received just as good care and feed the first year as at any subsequent time; but this first year is used as a basis for calculating their increase in the milk and butter yield, and no account is taken of any gain for that first year over previous years. Judging from the reports of the Cornell Experiment Station of New York before alluded to, the gain the first year must have been almost sufficient, calculating the increased value of the manure, to have paid for the grain consumed. If this be so the increase in the following years was nearly clear profit.

If the records of the cows the first year they were owned by the Station was all there was to show for the extra work and the outlay of money for feed, the outlook for more advanced methods in dairying would be rather discouraging; but the dairyman must not be discouraged from the results obtained in his first year's experience as the full results from the grain fed are not obtained the first year. Strange as it may seem the grain fed to a cow one year though it may show no appreciable increase in the milk yield at the time does prepare her for better service the following year. This increase in the value of the cow seems to be fairly steady from year to year, and it is a real question if it would not pay the dairyman better to confine his attention to systematically and liberally feeding the cows he already possesses, instead of placing all his faith on breed and endeavoring to increase the products of his herd by only introducing good dairy blood. There are many herds of so-called "native cows,' which could be brought to a well paying basis, if given the same attention and the same liberal feeding that the Station herd has received. These herds could be improved in less time by feeding than by breeding, as it takes at least four years to get a good cow by breeding to improved bulls. Nearly three years are required from the time the cow is bred until the heifer drops her first calf, and a heifer with her first calf is seldom much of an improvement over her mother. On the other hand in feeding a

herd to improve it, the returns commence to come in the second year, and by the fourth year the cow is almost as good as the grade raised under the other process. The cow improved by feeding is better than the grade which has not been systematically fed. Perhaps the better and surer way is to combine the two methods, letting breeding and feeding each have its influence, but it must not be forgotton that no substantial improvement can be made in a herd of cows without liberal and proper feeding no matter how good dairy bulls may be used. But of course all cows cannot be improved by feeding. With a cow like No. 4 considered in this bulletin, the tendency to lay on beef from the grain eaten is so strong that her dairy qualities fail to profitably respond to the feeding of a narrow ration.

There is still another side to the feeding question. It is a well known principle in breeding that all other things being equal the sheep with the finest wool, or the healthiest, strongest mare, will more surely produce offspring having the qualities of the dam. This principle will extend in some measure to the dairy cow that has through the proper management been brought to a high productive state. Her calves are more likely to make good dairy cows than calves from a dam whose qualities had been allowed to lie dormant. If this principle holds true, and it is reasonable to believe that it will, better grades can be obtained from a herd cared for as the Station herd has been, than in simply breeding up native cows, such as are found on farms of the State, and which have not been brought to their highest productive capacity.

COW NO. 29 (FROM PHOTOGRAPH).

THE MARYLAND

AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 70. January, 1901.

# THE CHEMICAL COMPOSITION OF MARYLAND SOILS.

BY F. P. VEITCH.

## LETTER OF TRANSMITTAL.

MR. H. J. PATTERSON,
*Director of the Agricultural Experiment Station,*
*College Park, Md.*

DEAR SIR:—I send you herewith manuscript entitled "The Chemical Composition of Maryland Soils" prepared by Mr. F. P. Veitch. I consider this one of the most important publications upon this difficult subject which has appeared in recent years. The work was done under my direction in the laboratory of the Division of Soils of the United States Department of Agriculture with the advice and assistance of Dr. F. K. Cameron, Soil Chemist of the Division, and had the endorsement of Dr. H. W. Wiley, Chief chemist of the department of Agriculture. I recommend that this be published as a bulletin of the Maryland Experiment Station.

Respectfully,

MILTON WHITNEY,
*Chief of Division.*

## IMPORTANCE, OBJECT, AND SCOPE OF SOIL WORK.

The maintenance of the fertility of the soil is the most importamt problem with which the experiment stations have to deal. That the importance of the problem is thoroughly appreciated is shown by the great amount of work done upon it during the past fifty years. Scientifically this work has consisted of numerous investigations upon the chemical and physical composition and properties of soils—many analyses have been made and many experiments tried. The total plant food of many soils has been determined and efforts have been made to distinguish the various forms in which it occurs. The relations of texture and structure to moisture and heat, and through these relations, to fertility, have been studied. Climate in its relation to fertility has also received its share of attention, and many interesting and important relations have been pointed out. Practically, the problem has been studied through innumerable experiments with many kinds of plants upon the effect of manures and fertilizers, which carry one or more of the essential plant foods in different chemical compounds and in varying amounts and proportions.

Numerous experiments have been conducted upon the amount and character of cultivation—whether it shall be frequent or seldom, shallow or deep, ridged or flat, firming or loosening. To this has been added studies of the conservation of moisture as affected by the various methods of cultivation. While the work that has been and is being done attests the importance of the problem before us, the most striking proof is to be found in the fact that in any given locality or State the average yield of crops is never equal to half the yield of the best farms in that same locality or State.

The census returns of the yield of the staple crops in Maryland for 1890 are:

| | Per acre bushels | Total yield bushels |
|---|---|---|
| Wheat | 16.56 | 8,348,177 |
| Corn | 25.44 | 14,928,142 |
| Oats | 20.4 | 2,010,658 |

What does doubling these figures mean to Maryland farmers?

That the deterioration of the soil's fertility is due to improper treatment rather than an absolute loss of an essential constituent is a generally accepted proposition; therefore, the permanent improvement of our soils can only be economically accomplished by a more complete knowledge of their individual needs and of the varying effects of chemical, physical and climatic conditions.

There are several directions from which the problem may be approached. Without going into details at this time it may be said that we have endeavored to make our work comprehensive. Our first object is to determine the *controlling* factor of fertility in the various soils of the State—whether and when this factor is physical, depending upon the color, texture, or structure of the soil; climatological, depending upon temperature, sunshine, and rainfall; or chemical, depending upon the ab-

solute chemical composition or upon a definite minimum solubility of the soil's constituents.

The problem is too complicated to suppose that any one property of soils is the invariable, unmodified, controlling factor in all soils. The controlling factor is that property or properties that unmistakably limit and determine crop production.

Since the days of Liebig, the "father of agricultural chemistry," it has been thought that a chemical examination alone of the soil would explain and suggest the remedy for impoverished soils. This opinion, still very generally held, must be abandoned as it is unfortunately incorrect. Were it true that all soils possessed the same physical properties, that is, were composed of particles having the same size, weight, color arrangement, and the same capacity to hold water and in addition were subjected to the same rainfall and other climatic conditions, then we might reasonably expect a chemical examination alone to explain their varying crop producing power. But with the widely different physical and climatic conditions, an isolated analysis as ordinarily carried out rarely furnishes data by which the crop producing power of a soil can be determined. When however the analysis is one of a series of soils of the same general physical nature and may be compared with others of very different character and productiveness, valuable information may be gained from it. This Station has frequently called attention to the fact that practically all soils contain enough of the various plant foods to enable them to produce maximum crops for hundreds of years to come, yet the every day experience of the farmer shows that the application of as little as from 20 to 30 pounds per acre of phosphoric acid, potash or nitrogen, may result in a large increase of crops. In fact the profitable production of crops seems to be seldom possible in Maryland without the application of some fertilizing material. This in the face of the fact that the soil may contain at that time several thousand pounds per acre of these same materials. If a soil that to a depth of one foot contains in one acre 14,000 pounds of potash and 3,000 pounds of phosphoric acid will produce five bushels of wheat per acre, why will the application of a few pounds of phosphoric acid, potash and nitrogen enable it to produce from 20 to 40 bushels per acre? What has caused this wonderful change? Is the effect a physical one alone? Has the texture, relation to heat, and moisture been so changed, or does the material exist in so much smaller particles that the increased production can be ascribed entirely to physical causes? Is the effect a chemical one. Do these added materials carry the plant food in a different condition, a condition that enables the plant to absorb it, a condition in which the plant food of the soil does not exist? Do these added materials act chemically upon the soil, changing the conditions and rendering the plant food of the soil more useful to the plant? Beyond the fact that fertilizing materials must be applied in certain soluble forms, and that such increase of crops is produced, we know comparatively little of the nature of the action of fertilizers—whether the action is principally physical or chemical has not been settled.

For want of a better term, we call that plant food taken up by plants "available plant food." To determine the available plant food of the soil we must grow crops upon it, not one crop but many crops of various kinds

and for a number of years. To say the least this is a long, tedious and expensive process, and to overcome the difficulty investigators have been seeking for years for a chemical or physical method that would serve the purpose. While much valuable information has been obtained and much help given the farmer, a reliable physical or chemical method for determining the crop producing power of a soil has not been worked out as yet. To the unitiated this may seem strange, but when it is remembered that not one but hundreds of able men—both scientists and farmers—the world over have been engaged for years upon this problem, some idea of difficulties encountered may be obtained.

In previous bulletins of this series Professor Whitney has dealt with the physical and climatological properties of the various formations. How and when these properties become the controlling factors in the profitable production of crops has been pointel out and thoroughly explained. The relation of the chemical properties to fertility will be discussed in this bulletin. While the classification of the soils of Maryland by their physical properties is of value and, broadly speaking, corresponds with the agricultural capabilities of the soil, yet as with all other classifications there are some points that are not completely explained thereby.

In agricultural research there is no branch of natural science which is not of service to the investigator; and in connection with the previous work the chemical investigation of these soils, as reported in this bulletin, follows as a matter of course.

### PURPOSE AND METHODS OF CHEMICAL EXAMINATIONS.

The purpose of the agricultural chemical examination of soils is to throw light upon the relations of the several constituents to plant growth, especially to determine the amounts of these constituents that are in such condition that the plant can use them. Further, from the data furnished by this and previous examinations of these soils, it is hoped to see more clearly the relative effect of chemical and physical conditions upon fertility and to obtain a more detailed classification of Maryland soils than has yet been possible.

Incidentally a study of the several methods, as to their suitability for their respective purposes is involved.

Three different methods each having a different end in view and each independent of the other, have been used so far in the chemical work upon Maryland soils.

These methods are:

The Fusion Method*

The Concentrated (1.115 sp.gr.) Hydrochloric Acid Method.**

The Fifth Normal (about ¾ %) Hydrochloric Acid Method**

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*For details see Bulletin 148 U. S. Geological Survey.

**For details see Bulletin 46 Revised, Division of Chemistry, U. S. Department of Agriculture.

While it has long been known that the Fusion Method only shows the absolule composition of the soil without any reference to the constitution of its several compounds and with still less reference to their availability for plants, yet the use of this method is necessary to furnish a basis in such work as the determination of the comparative solubility of the several constituents in various solutions and the identification of those compounds existing in the soil.

The method of digesting with strong hydrochloric acid is believed to be the best method now at our command for the purpose of dissolving and separating these compounds that at the present time constitute the soil's total productive power. Not all of this matter is immediately available to plants, in fact but little of it may be; but all of it is in such chemical and physical condition that through cultivation, the action of organic matter and natural agencies, any portion may be rendered available. With each succeeding year or with changing conditions other portions of this material may be further broken down and taken up by vegetation or removed by drainage waters. Chemically, the separation is not a very sharp one. All the soil compounds are more or less soluble in this reagent. Those that are completely broken down and dissolved are the ones that the method is intended to determine, but the more difficultly soluble compounds are also partially dissolved. The rate and the degree of solubility of the various compounds are controlled by the concentration of the acid and by the time and temperature of the treatment. The relation of these several factors which produces the maximum solubility has been experimentally determined, and this relation is strictly observed in the execution of the method.

Much explanatory and suggestive data have been secured by the use of this method upon soils whose crop values were known in a general way. Used in conjunction with a physical examination of the soil and a close and intelligent observation of plant distribution, valuable information of practical nature may be obtained.

The Fifth Normal Hydrochloric Acid Method is one of several modifications of the method just described which is used to determine the relative amounts of the essential mineral plant foods that are immediately available to plants. Bearing in mind the relation of the results obtained by the use of these methods, to fertility, it is very important to understand clearly their purpose and claims. It is not claimed that methods of this class show the exact amount of food which a plant will remove in a season. As a matter of fact they all show many times as much, even in the poorest soil, as any plant can possibly obtain under normal conditions. Therefore the results by methods of this character are simply comparative, and all that is claimed for them is that if one soil, yielding to one of these methods so much potash and phosphoric acid, produces a given crop under certain conditions, then a soil yielding to the same method more potash and more phosphoric acid may be expected to produce larger crops under the same conditions.

It is customary to determine by this method, only the amount of potash and phosphoric acid dissolved, but hoping to show the influence of other readily soluble constituents—notably, lime, magnesia, iron, and alumina—the work herewith reported has been more complete and all those constituents which were dissolved have been determined. Further, the additional data will enable us to compare the solubility of each constituent in the acids of different strengths and may throw some light upon the constitution of the soil compounds.

## DESCRIPTION OF SAMPLES.

Fifty samples selected in accordance with the relative extent and agricultural value, of sixteen of the most important soil formations of the state were chosen and prepared for analysis. In all cases these samples represent the subsoil taken immediately under the top soil. Subsoils rather than soils were chosen for this work, because cultivation, vegetation, and fertilization exert marked influences on the soil, changing the solubility and increasing or decreasing the amounts of the various compounds present. This is particularly true of the compounds containing nitrogen, lime, potash or phosphoric acid. While the composition of the subsoil is not constant, being changed by the same influences that affect the soil, this change is not nearly so great as in the case of soils. Consequently subsoils are assumed to be more uniform than soils, therefore are better adapted to comparative studies.

The number of samples from each geological formation, with the typical crop produced by them is given in the following table:

TABLE I.

*Maryland Soil Formations.*

| No. of Samples | Geological formation | Typical crops. |
|---|---|---|
| 4 | Columbia | Truck (Southern Maryland) |
| 2 | Chesapeake and Columbia (?) | Truck (Eastern Shore) |
| 4 | Chesapeake | Tobacco |
| 4 | Chesapeake | Corn and wheat |
| 3 | Columbia | Corn and wheat |
| 5 | Chesakeake and Columbia(?) | Corn and wheat |
| 1 | Hudson River Shale | Corn and wheat |
| 4 | Gneiss | Corn and wheat |
| 4 | Gabbro | Wheat and grass |
| 4 | Helderberg Limestone | Wheat and grass |
| 4 | Catskill | Wheat and grass |
| 3 | Triassic | Grass |
| 8 | Trenton limestone | Grass |
| 4 | Cambrian | Fruit |
| 1 | Lafayette | Barrens |
| 2 | Serpentine | Barrens |
| 3 | Potomac clay. | Barrens |

## GENERAL GEOLOGY AND COMPOSITION.

Following the custom established in former bulletins the samples will be discussed in groups, designated by the typical crops grown upon the several soils, and within these general groups they will be arranged with respect to their geological formations.

A detailed description of the physiology and geology of these various formations may be found in Volume I of the Maryland Geological Survey. Their physical and mechanical properties and the classification upon their suitability for various crops have been treatad at length in preceding bulletins of this Station.** Their general outline and location are shown upon the geological and agricultural map published by the Maryland State Weather Service which is also published in connection with the work entitled "Maryland, its Resources, Industries and Institutions," prepared, and published for the Chicago World's Fair. Here, therefore, we shall deal but briefly with these subjects.

Three great physiographic regions of the East cross the State from northeast to southwest—these are the Coastal Plains, the Piedmont Plateau, and the Appalachian region.

The Coastal plains embrace the southern and eastern portions of the state and extend southward from a line through Washington, Baltimore and Wilmington coveringWorcester, Wicomico, Dorchester, Caroline, Somerset,Queen Anne,Talbot, Kent, Charles, Calvert, St. Mary, Anne Arundel, Prince George,and the southern part of Baltimore,Harford and Cecil counties. The area is about 5,000 square miles, or about one-half of the land area of the State. It consists principally of low lying plains and on the Eastern Shore seldom reaches a height of 100 feet in the north, while in the south most of it is less than 25 feet above tide. Upon the Western shore it rises to an elevation of 300 feet or more.

The Piedmont Plateau extends from the Coastal Plains on the east to the foot of the Catoctin Mountains on the west. It embraces about 2,500 square miles and includes Montgomery, Carroll, Howard and most of Frederick, Baltimore, Harford and Cecil counties. The surface is much broken by low undulating hills which reach the greatest height about the central portion in Paris Ridge, beyond which it gradually slopes to the Frederick Valley. The soils of the region are all derived from more or less crystalline rocks.

The Appalachian region extends westward from Catoctin Mountains. Its area is about 2,000 square miles and includes western Frederick and Washington, Allegany and Garrett counties. The surface is much broken, consisting of a succession of narrow valleys and high mountains extending in a northeasterly and southwesterly direction. West of Hagerstown Valley the lands except in the valleys are generally rocky, steep and difficult to work, though very productive and profitable when planted with crops to which they are suited.

**Annual Report 1891, Bulletins 21, 29, 41.

## TRUCK SOILS.

*Columbia Formation*—The truck soils of the Columbia formation widely cover the other formations of the Coastal Plains and extend from the glacial accumulations of New Jersey through the southern Atlantic and Gulf States to Mexico. This formation varies greatly in composition, texture and depth, being finest and thickest over the northern part of the Eastern shore and over the high lands of the Coastal Plains,on the western shore. Over the lower part of the shore and on the low lying river necks in general it is thinner and more sandy. It is these sands that constitute the early truck soils throughout the whole seaboard. The physical condition of these soils is such that they will maintain only from 5 to 6 per cent of moisture. They are well drained and warm, thus forcing the crop to early maturity—an essential point in the profitable production of early truck.

The bulk analyses show these soils to be very low in organic matter, low in potash and rather low in lime and phosphoric acid. Practically no water is held by the air-dry soil. It is the general experience with these soils that the most profitable fertilizers to use are organic matter in the form of stable manure, potash salts, lime and phosphoric acid, in the order named. The lowest amount of potash is equal to about 11,000 pounds per acre to a depth of one foot. Lime is equal to about 11,000 pounds and phosphoric acid to 600 pounds.

Between the truck soils and the tobacco soils lay the heavy truck and fruit soils, of which so far we have made no chemical study. Their mechanical composition has been treated in former bulletins.

TABLE II.

*Mechanical and Chemical Analyses of Truck Soil.*

| Conventional name | Diameter m.m. | EASTERN SHORE 1213 Salisbury, Md. | EASTERN SHORE 1223 Concord, Md. | WESTERN SHORE. 472 Marley, Md. | WESTERN SHORE. 577 Magothy Neck Md. | WESTERN SHORE. 815 Waterbury, Md. | WESTERN SHORE. 467 Shipley, Md. |
|---|---|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | | | |
| | | per cent | per cent | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | 1.91 | 0.99 | .49 | 1.52 | .63 | 0.76 |
| Coarse Sand | 1–.5 | 6.43 | 6.94 | 4.96 | 4.50 | 5.73 | 8.55 |
| Medium sand | .5–.25 | 32.95 | 33.29 | 40.19 | 29.88 | 38.01 | 35.04 |
| Fine Sand | .25–.1 | 33.69 | 31.36 | 27.59 | 23.77 | 28.69 | 19.26 |
| Very fine sand | .1–.05 | 10.22 | 9.05 | 12.10 | 10.36 | 10.31 | 8.42 |
| Silt | .05–.01 | 9.15 | 10.24 | 7.74 | 17.16 | 10.26 | 11.38 |
| Fine silt | .05–.005 | 2.08 | 2.81 | 2.23 | 3.83 | 1.81 | 4.13 |
| Clay | .005–.0001 | 2.60 | 2.97 | 4.40 | 8.01 | 3.20 | 10.09 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | | | |
| Silica | $SiO_2$ | 91.46 | 88.38 | 95.66 | 93.18 | 92.84 | 91.37 |
| Potash | $K_2O$ | 1.17 | .94 | .37 | .46 | .58 | .39 |
| Soda | $Na_2O$ | .90 | .98 | .24 | .18 | .23 | .13 |
| Lime | CaO | .34 | .50 | .38 | .40 | .44 | .09 |
| Magnesia | MgO | .24 | .55 | .35 | .30 | .30 | .12 |
| Manganese Oxid | MnO | .06 | .10 | .02 | .10 | .12 | ...... |
| Ferric Oxid | $Fe_2O_3$ | .66 | .84 | .40 | 1.70 | .96 | 5.24 |
| Alumina | $Al_2O_3$ | 4.15 | 5.12 | 2.00 | 1.94 | 2.80 | |
| Phosphoric Acid | $P_2O_5$ | .02 | .04 | .06 | .08 | .06 | .05 |
| Sulphuric Acid | $SO_3$ | .04 | .04 | .06 | .09 | .15 | ...... |
| Carbon Dioxid | $CO_2$ | .06 | .12 | .13 | .05 | .06 | ...... |
| Water | $H_2O$ | .20 | .38 | .14 | .20 | .24 | ...... |
| Volatile | | .65 | 2.48 | .78 | 1.18 | 1.04 | 1.90 |
| | | 100.04 | 100.47 | 100.59 | 99.86 | 99.82 | 99.29 |

## TOBACCO SOILS.

*Chesapeake Formation.*—This formation constitutes the underlying strata of nearly all the coastal plains, and though covered in the lower levels by the Columbia formation, it gives rise to the best soils of Southern Maryland in the high valleys. On the western shore the formation is quite extensive in the lower Potomac and Patuxent valleys throughout Prince George county, and also around Bristol and Davidsonville in Anne

Arundel county. On the Eastern Shore it occurs in quite a wide belt on either side of Centreville, Church Hill, Crumpton and Millington. The limits of the various soils have not yet been worked out, but according to position and texture it gives rise to at least two types of soil; one containing from 10 to 18 per cent. of clay forms the finest tobacco lands of the State; the other, containing more than 18 per cent. of clay, is suitable for wheat and grass.

TABLE III.

*Mechanical and Chemical Analyses of Tobacco Soils of Chesapeake Formation.*

| Conventional Name | Diameter m m. | 164 North Keys, Md | 262 Chaneyville, Md. | 266 Chaneyville, Md. | 258 Upper Marlboro, Md. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2-1 | .58 | .00 | 1.40 | 1.53 |
| Coarse sand | 1-.5 | .50 | .07 | 2.94 | 5.67 |
| Medium sand | .5-.25 | 1.35 | 1.56 | 11.23 | 13.25 |
| Fine sand | .25-.1 | 10.65 | 13.51 | 13.42 | 8.39 |
| Very fine sand | .1-.05 | 37.61 | 37.73 | 19.32 | 14.95 |
| Silt | .05-.01 | 22.00 | 18.82 | 17.59 | 58.86 |
| Fine silt | .01-.005 | 7.81 | 6.18 | 5.44 | 7.84 |
| Clay | .005-.0001 | 16.02 | 18.79 | 10.72 | 14.55 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 80.10 | 84.28 | 90.48 | 80.59 |
| Potash | $K_2O$ | 1.22 | .86 | .65 | .94 |
| Soda | $Na_2O$ | .70 | .70 | .45 | .38 |
| Lime | $CaO$ | .35 | .78 | .46 | .31 |
| Magnesia | $MgO$ | .64 | .54 | .24 | .36 |
| Manganese Oxid. | $MnO$ | .04 | .18 | .16 | ...... |
| Feric Oxide | $Fe_2O_3$ | 3.10 | 2.44 | 1.36 | 3.62 |
| Alumina | $Al_2O_3$ | 8.91 | 6.60 | 4.23 | 6.64 |
| Phosphoric Acid. | $P_2O_5$ | .15 | .32 | .18 | .27 |
| Sulphuric Acid | $SO_3$ | .15 | .09 | .11 | ...... |
| Carbonic Acid | $CO_2$ | .04 | .07 | .05 | ...... |
| Water | $H_2O$ | 1.64 | 1.57 | .67 | ...... |
| Volatile | | 3.31 | 2.08 | 1.57 | 5.06 |
| | | 100.34 | 100.13 | 100 24 | 98.17 |

An examination of the table shows a rather low percentage of potash, medium amount of lime, medium amount of phosphoric acid, and a low percentage of organic matter. To a depth of one foot there is in an acre fron 19,000 to 36,000 pounds of potash, 11,000 to 14,000 pounds of lime, and 4,500 to 10,000 pounds of phosphoric acid. The soils average about 85 per cent of silica and 15 per cent of clay. No 262 is the finest grade of tobacco land.

## CORN AND WHEAT SOILS.

*Columbia Formation.*—The geological position of the formation has been described in speaking of the truck soils. The corn and wheat soils of the Columbia lay at higher levels than the truck soils of the same formation and lower than the Chesapeake formation. They constitute the river terraces, lying at an elevation of 20 to 60 feet above tide, and are about one-half mile wide. Some of the lands around St. Mary have been cultivated for more than 200 years without apparent deterioration. Neither the mechanical nor chemical analysis, as compared with other soils, account for this fertility. The percentage of clay in these soils averages about 25 per cent. In an acre to a depth of one foot there is from 37,000 to 40,000 pounds of potash, 16,000 to 19,000 pounds of lime, and 400 to 500 pounds of phosphoric acid. These soils contain about 3.25 per cent. of organic matter an 80 per cent. of silica.

TABLE IV.

*Mechanical and Chemical Analyses of Corn and Wheat Soils of Columbia Composition.*

| Conventional Name | Diameter m m. | 199 Opposite Ben'dict, Md. | 205 Opposite St. Mary, Md. | 201 St. Mary, Md. |
|---|---|---|---|---|
| MECHANICAL ANALYSES | | | | |
| | | per cent | per cent | per cent |
| Gravel | 2–1 | .38 | .41 | .44 |
| Coarse sand | 1–.5 | 2.72 | .42 | 1.05 |
| Medium sand | .5–.25 | 11.64 | 1.64 | 2.67 |
| Fine Sand | .25–.1 | 7.23 | 3.45 | 5.03 |
| Very fine Sand | .1–.05 | 6.74 | 9.48 | 9.75 |
| Silt | .05–.01 | 33.92 | 41.88 | 34.82 |
| Fine silt | .01–.005 | 10.62 | 11.98 | 4.52 |
| Clay | .005–.0001 | 23.45 | 26.24 | 25.03 |
| ULTIMATE CHEMICAL ANALYSES. | | | | |
| Silica | $SiO_2$ | 81.74 | 80.24 | 79.66 |
| Potash | $K_2O$ | 1.32 | 1.25 | 1.09 |
| Soda | $Na_2O$ | .46 | .56 | .44 |
| Lime | CaO | .54 | .65 | .23 |
| Magnesia | MgO | .25 | .31 | .32 |
| Manganese oxid | MnO | .13 | .10 | ...... |
| Ferric oxid | $Fe_2O_3$ | 2.64 | 2.70 | 13.08 |
| Alumina | $Al_2O_3$ | 8.18 | 9.46 | |
| Phosphoric acid | $P_2O_5$ | .18 | .14 | .94 |
| Sulphuric acid | $SO_3$ | .04 | .09 | ...... |
| Carbonic acid | $CO_2$ | .06 | .03 | ...... |
| Water | $H_2O$ | 1.24 | 1.32 | ...... |
| Volatile | | 3.22 | 3.30 | 4.84 |
| | | 100.00 | 100.07 | 99.70 |

*Chesapeake Formation.*—The location and extent of this formation has been spoken of under tobacco lands. The corn and wheat lands differ apparently, from the tobacco lands only in texture, though the corn and wheat soils are confined to the diatomaceous marls of this formation. As before stated, these soils are the strongest and most valuable of Southern and Eastern Maryland. In fact, they are hardly, if at all, surpassed by the heavier limestone soils of the State in lasting properties. These soils average about 30 per cent of clay, and contain in one acre, to a depth of one foot, from 23,000 to 46,000 pounds of potash, 3,300 to 17,000 pounds of lime, and 4,000 to 8,000 pounds of phosphoric acid. They contain about 3 per cent of organic matter and about 75 per cent. of silicia.

TABLE V.

*Mechanical and Chemical Analyses of Wheat Soils of Southern Maryland. Chesapeake Formation.*

| Conventional Name | Diameter m.m. | 179 Herring Bay, Md. | 184 Popes Creek, Md. | 247 Davidsonville Md. | 245 Davidsonville Md. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | .00 | .00 | .00 | .82 |
| Coarse sand | 1–.5 | .00 | .46 | .27 | .28 |
| Medium sand. | .5–.25 | .50 | 6.61 | .64 | .98 |
| Fine sand | .25–.1 | 3.50 | 12.19 | 3.20 | 1.74 |
| Very fine sand | .1–.05 | 36.28 | 9.15 | 22.58 | 52.74 |
| Silt | .05–.01 | 19.04 | 30.89 | 26.25 | 16.91 |
| Fine silt | .01–.005 | 6.78 | 13.22 | 10.42 | 3.35 |
| Clay | .005–.0001 | 32.42 | 24.45 | 32.40 | 19.57 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 76.62 | 81.84 | 75.68 | 85.44 |
| Potash | $K_2O$ | 1.20 | 1.09 | 1.52 | .76 |
| Soda | $Ma_2O$ | .54 | .36 | .65 | .46 |
| Lime | CaO | .50 | .56 | .47 | .11 |
| Magnesia | MgO | .85 | .50 | .84 | .08 |
| Manganese oxid | MnO | .06 | .06 | .11 | ...... |
| Ferric oxid | $Fe_2O_3$ | 3.20 | 2.54 | 4.04 | 2.95 |
| Alumina | $Al_2O_3$ | 9.93 | 9.12 | 10.88 | 6.11 |
| Phosphoric acid | $P_2O_5$ | .27 | .14 | .18 | .18 |
| Sulphuric acid | $SO_3$ | .08 | .08 | .08 | ...... |
| Carbonic acid | $CO_2$ | .09 | .10 | .04 | ...... |
| Water | $H_2O$ | 2.79 | .84 | 1.48 | ...... |
| Volatile | | 4.02 | 2.84 | 3.96 | 4.16 |
| | | 100.12 | 100.07 | 99.83 | 100.25 |

*Corn and Wheat Soils of the Eastern Shore*—These soils are either of the Chesapeake or Columbia formation, probably of the Columbia. They cover most of the highest portion of the Eastern Shore north of Cambridge. To the south they occur in isolated tracts in the light truck lands of this region. They are rather lighter physically and chemically than similar soils of the western shore, and probably represent the limit of profitable corn and wheat lands. In fact the particular regions from which these samples came are more famous for fruit than for corn and wheat. They would probably produce a good grade of tobacco. The location and limits of these isolated areas have not yet been worked out. These soils contain about 15 per cent of clay, 3 per cent of organic matter, and 80 per cent of silica. In one acre to a depth of one foot there is from 27,000 to 50,000 pounds of potash, 9,000 to 16,000 pounds of lime, and 600 to 2700 pounds of phosphoric acid.

TABLE VI.

*Mechanical and Chemical Analyses of the Corn and Wheat Soils of the Eastern Shore, Maryland.*

| Conventional Name | Diameter m.m. | 767 Chertertown, Md. | 1127 Cambridge, Md. | 1135 Linkwood, Md. | 1165 Centreville, Md. | 1181 Wye Mills, Md. |
|---|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | | |
| | | per cent | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | .00 | .10 | .53 | .33 | .00 |
| Coarse sand | 1–.5 | .43 | 1.46 | 3.98 | .74 | .32 |
| Medium Sand | .5–.25 | 1.67 | 14.41 | 21.80 | 3.39 | .69 |
| Fine sand | .25–.1 | 1.81 | 20.82 | 14.32 | 4.51 | .68 |
| Very fine sand | .1–.05 | 14.47 | 9.74 | 8.00 | 22.26 | 17.26 |
| Silt | .05–.01 | 48.66 | 29.17 | 30.56 | 42.91 | 45.54 |
| Fine Silt Clay | .01–.005 | 7.06 | 3.12 | 7.01 | 4.72 | 8.96 |
| Clay | .005–.0001 | 20.02 | 17.07 | 12.82 | 14.56 | 15.14 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | | |
| Silica | $SiO_2$ | 74.92 | 83.48 | 86.04 | 76.94 | 72.04 |
| Potash | $K_2O$ | 1.58 | 1.38 | .92 | 1.70 | 2.05 |
| Soda | $Na_2O$ | .83 | .97 | .71 | .54 | .80 |
| Lime | CaO | .32 | .46 | .50 | .54 | .53 |
| Magnesia | MgO | .77 | .26 | .27 | .76 | .83 |
| Manganese oxid | MnO | .16 | .20 | .00 | .14 | .14 |
| Ferric oxid | $Fe_2O_3$ | 3.56 | 1.60 | 1.36 | 2.60 | 3.70 |
| Alumina | $Al_2O_3$ | 12.19 | 8.15 | 7.21 | 12.11 | 14.17 |
| Phosphoric acid | $P_2O_5$ | .09 | .02 | .09 | .05 | .03 |
| Sulphuric acid | $SO_3$ | .10 | .07 | .13 | .10 | .08 |
| Carbonic acid | $CO_2$ | .06 | .08 | .08 | .06 | .04 |
| Water | $H_2O$ | 1.30 | .82 | .68 | .92 | 1.80 |
| Volatile | | 3.76 | 2.40 | 2.18 | 3.61 | 4.02 |
| | | 99.64 | 99.92 | 100.17 | 100.07 | 100.21 |

*Hudson River Shale Formation.*—This occurs in the western part of Washington county, the largest area being the region drained by the Conocheague Creek. Other smaller areas lie further west beyond Clear Spring. The formation consists of fine grained, black and gray calcareous shales. They contain a high percentage of carbonate of lime and have weathered rapidly where exposed. These soils contain about 22 per cent of clay, 5 per cent of organic matter, and 70 per cent of silica. In one acre to a depth of one foot there are about 75,000 pounds of potash, 19,000 pounds of lime, and 3,600 pounds of phosphoric acid.

TABLE VII.

*Mechanical and Chemical Analyses of Corn and Wheat Soils of Hudson River Shale Formation.*

| Conventional Name | Diameter m.m. | 919 Williamsport, Md. |
|---|---|---|
| MECHANICAL ANALYSES. | | |
| | | per cent |
| Gravel | 2–1 | 1.85 |
| Coarse sand | 1–.5 | 3.38 |
| Medium sand | .5–.25 | 6.08 |
| Fine sand | .25–.1 | 10.45 |
| Very fine sand | .1–.05 | 20.69 |
| Silt | .05–.01 | 23.84 |
| Fine silt | .01–.005 | 6.61 |
| Clay | .005–.0001 | 21.56 |
| ULTIMATE CHEMICAL ANALYSES | | |
| Silica | $Si_2O$ | 69.94 |
| Potash | $K_2O$ | 2.52 |
| Soda | $Na_2O$ | .59 |
| Lime | $CaO$ | .64 |
| Magnesia | $MgO$ | .89 |
| Manganese oxid | $MnO$ | .06 |
| Ferric oxid | $Fe_2O_3$ | 6.04 |
| Alumina | $Al_2O_3$ | 13.60 |
| Phosphoric acid | $P_2O_5$ | .12 |
| Sulphuric acid | $SO_3$ | .15 |
| Carbonic acid | $CO_2$ | .08 |
| Water | $H_2O$ | 1.36 |
| Volatile | | 4.56 |
| | | 100.55 |

*Gneiss Formation.*—This is one of the largest exposed areas of the State and constitutes the greater part of Montgomery, Howard, Baltimore and Harford counties; also large areas in Carroll and Cecil counties. On the east, where it follows roughly the line of the Baltimore and Ohio railroad from Washington, D. C., to Wilmington, Del., it is easily distinguished from the Potomac formation, and its western border is a nearly straight line from the Potomac through Gaithersburg, Lisbon, and Thurmont, to the Pennsylvania line. Within this area more or less prominent areas of limestone, granite, serpentine and gabbro soils are observed.

These soils contain about 25 per cent of clay, 6 per cent of organic matter, and 65 per cent. of silica. In one acre, to a depth of one foot, there are from 25,000 to 51,000 pounds of potash, 8,000 to 14,000 pounds of lime, and 900 to 2,700 pounds of phosphoric acid.

TABLE VIII.

*Mechanical and Chemical Analyses of Corn and Wheat Soils of Gneiss Formation.*

| Conventional Name | Diameter m.m. | 1049 Rocky Run Church, Md. | 1256 Churchill, Md. | 3013 Emmerton, Md. | 1045 Glenville, Md. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | 1.41 | 10.67 | 1.02 | .19 |
| Coarse sand | 1–.5 | 2.36 | 2.57 | 1.73 | 1.80 |
| Medium sand | .5–.25 | 4.54 | 2.40 | 2.33 | 3.12 |
| Fine sand | .25–.1 | 3.94 | 5.63 | 5.87 | 6.96 |
| Very fine sand | .1–.05 | 10.13 | 9.99 | 24.88 | 8.76 |
| Silt | .05–.01 | 45.94 | 35.24 | 15.13 | 34.92 |
| Fine silt | .01–.005 | 6.50 | 8.34 | 5.32 | 12.14 |
| Clay | .005–.0001 | 20.06 | 19.64 | 34.83 | 28.82 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 71.50 | 67.77 | 54.80 | 68.93 |
| Potash | $K_2O$ | 1.68 | 1.42 | .84 | 1.51 |
| Soda | $Na_2O$ | .65 | .30 | .42 | .97 |
| Lime | $CaO$ | .44 | .44 | .26 | .54 |
| Magnesia | $MgO$ | .29 | 1.00 | .38 | .32 |
| Manganese oxid | $MnO$ | .12 | .09 | .08 | ...... |
| Ferric oxid | $Fe_2O_3$ | 4.40 | 5.54 | 10.56 | 4.98 |
| Alumina | $Al_2O_3$ | 14.51 | 16.58 | 20.88 | 14.70 |
| Phosphoric acid | $P_2O_5$ | .09 | .08 | .08 | .03 |
| Sulphuric acid | $SO_3$ | .37 | .07 | .07 | ...... |
| Carbonic acid | $CO_2$ | .08 | .10 | .09 | ...... |
| Water | $H_2O$ | 1.38 | 1.72 | 2.82 | ...... |
| Volatile | | 4.70 | 5.04 | 8.52 | 6.37 |
| | | 100.21 | 100.15 | 99.80 | 98.35 |

## WHEAT AND GRASS SOILS.

*Gabbro Formation*—There are three main areas of these soils in Maryland. One extends from the Western Maryland Railroad south of Pikesville in a wide belt around Catonsville to Ellicott City and in broken areas even as far south as Laurel. Another extends in a belt about four miles wide from four miles north of Loreley near the Gunpowder River, through Belair, Darlington, and Rising Sun to the Pennsylvania line, the other, a wide sheet, extends southwesterly from Conowingo nearly to Bush River. Other small areas occur throughout the Gneiss formation as far south as the Potomac. The formation is easily distinguished by the black, hard, heavy boulders which abound.

These soils contain about 32 percent of clay, 8 per cent of organic matter, and about 60 per cent silica. No. 132 is remarkable for containing so much alumina. In one acre to a depth of one foot there are from 12,000 to 25,000 pounds of potash, 12,000 to 28,000 pounds of lime, and 900 to 4,900 pounds of phosphoric acid.

TABLE IX.

*Mechanical and Chemical Analyses of Wheat and Grass Soils of Gabbro Formation.*

| Conventional Name | Diameter m.m. | 132 Mt. Hope, Md. | 1928 Havre de Grace, Md. | 2977 Gibson, Md. | 1025 Havre de Grace, Md. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | .00 | 1.11 | .46 | .13 |
| Coarse sand | 1–.5 | .18 | 1.11 | .87 | .28 |
| Medium sand | .5– 25 | .60 | 1.14 | 1.41 | 1.67 |
| Fine sand | .25–.1 | 3.66 | 3.29 | 2.51 | 6.59 |
| Very fine sand | .1–.05 | 11.35 | 14.45 | 8.93 | 20.64 |
| Silt | .05–.01 | 23.43 | 31.33 | 39.51 | 32.28 |
| Fine silt | .01–.005 | 3.01 | 8.48 | 7.59 | 3.35 |
| Clay | .005–.0001 | 38.90 | 29.79 | 28.58 | 25.35 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 37.98 | 64.04 | 58.60 | 66.27 |
| Potash | $K_2O$ | .41 | 1.06 | 1.24 | .86 |
| Soda | $Na_2O$ | .48 | .92 | 1.00 | .40 |
| Lime | $CaO$ | .44 | .74 | .40 | .24 |
| Magnesia | $MgO$ | .69 | .51 | 1.38 | .43 |
| Manganese oxid | $MnO$ | .04 | .12 | .10 | ...... |
| Ferric oxid | $Fe_2O_3$ | 12.70 | 4.96 | 7.56 | 6.97 |
| Alumina | $Al_2O_3$ | 32.07 | 19.96 | 19.67 | 15.25 |
| Phosphoric acid | $P_2O_5$ | .13 | .08 | .03 | .07 |
| Sulphuric acid | $SO_3$ | .11 | .10 | .07 | ...... |
| Carbonic acid | $CO_2$ | .09 | .19 | .07 | ...... |
| Water | $H_2O$ | 4.02 | .33 | 2.34 | ...... |
| Volatile | | 10.88 | 7.24 | 7.54 | 8.20 |
| | | 100.04 | 100.25 | 100 00 | 98.69 |

*Helderberg Limestone Formation*—This formation occurs in many narrow valleys westward in Washington and Allegany counties. Usually the soils are not of great depth but are very fertile. They contain about 30 per cent of clay, 5 per cent of organic matter, and 70 per cent of silica. In one acre, to a depth of one foot, there are from 30,000 to 91,000 pounds of potash, 13,000 to 23,000 pounds of lime, and 900 to 7,000 pounds of phosphoric acid.

TABLE X.

*Mechanical and Chemical Analyses of Wheat and Grass Soils of Helderberg Limestone Formation.*

| Conventional Name | Diameter, m m. | 220 Hancock, Md. | 223 Hancock, Md | 3492 Twigtown, Md. | 288 Type Sample, Md. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2-1 | 1.67 | .45 | .25 | 1.34 |
| Coarse Sand | 1-.5 | 5.53 | .97 | .80 | .33 |
| Medium sand | .5-.25 | 4.16 | 2.95 | 1.20 | 1.08 |
| Fine Sand | .25-.1 | 4.03 | 10.69 | 3.76 | 1.02 |
| Very fine sand | .1-.05 | 12.01 | 16 07 | 12.84 | 6.94 |
| Silt | .05-.01 | 30.71 | 26.89 | 37.15 | 29.05 |
| Fine Silt | .01-.005 | 10.28 | 6.78 | 7.98 | 11.03 |
| Clay | .005-.0001 | 25.32 | 29.40 | 29.22 | 43.44 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 67.34 | 72.33 | 72.90 | 66.17 |
| Potash | $K_2O$ | 3.04 | 1.52 | 2.56 | 1.06 |
| Soda | $Na_2O$ | .58 | .51 | 44 | .62 |
| Lime | $CaO$ | .44 | .76 | .46 | .44 |
| Magnesia | $MgO$ | .91 | .66 | 1.10 | .94 |
| Manganese oxid | $MnO$ | .30 | .10 | .22 | ...... |
| Ferric oxid | $Fe_2O_3$ | 5.80 | 5.30 | 3.96 | 6.61 |
| Alumina | $Al_2O_3$ | 14.81 | 12.46 | 10.45 | 16.31 |
| Phosphoric acid | $P_2O_5$ | .17 | .11 | .23 | .03 |
| Sulphuric acid | $SO_3$ | .10 | .09 | .04 | ...... |
| Carbonic acid | $CO_2$ | .13 | .09 | .13 | ...... |
| Water | $H_2O$ | 1.10 | 1.66 | 1.22 | ...... |
| Volatile | | 5.82 | 4.34 | 5.92 | 7.27 |
| | | 100.54 | 99.97 | 99.67 | 99.55 |

*Catskill or Hampshire Formation*—This formation occurs in the valleys and on the mountain side of the western part of Washington county and in Allegany and Garrett counties, the largest area forming a large Y in Garrett county along the eastern mountain sides of the Youghiogheny River and along the western slope of Savage Creek. This is a thin bedded sandstone mixed with a fine-grained shale. In the valleys it is very similar to the Triassic in its wheat and grass producing power. From its elevation on the slopes it is preeminently suited to fruit, and the soils of these slopes may be classed with the fruit soils. The apple thrives here in all its perfection.

These soils contain about 32 per cent. of clay, 4 per cent. of organic matter, and 70 per cent. of silica. In one acre, to a depth of one foot, there are from 60,800 to 120,000 pounds of patash, 6,000 to 21,000 pounds of lime, and 1,100 to 4,500 pounds of phosphoric acid.

TABLE XI.

*Mechanical and Chemical Analyses of Wheat and grass Soils of Catskill Formation.*

| Conventional Name. | Diameter, m. m. | 3522 Composite Sample, Allegany co., Md | 3524 Composite Sample, Allegany co.: Md. | 3533 Accident, Md. | 3535 Brookside, W. Va. |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | 3.03 | 1.83 | .57 | .00 |
| Coarse sand | 1–.5 | 3.06 | 2.59 | .84 | .54 |
| Medium sand. | .5–.25 | 2.91 | 4.01 | 1.05 | .39 |
| Very fine sand | .25–.1 | 11.66 | 14.98 | 1.95 | 2.07 |
| Silt | .1– 05 | 19.88 | 19.07 | 7.90 | 22.73 |
| Fine silt | .05–.01 | 30.41 | 21.22 | 17.55 | 27.42 |
| Clay | .01– 005 | 6.25 | 6.53 | 12.16 | 6.08 |
| Fine sand | .005–.0001 | 19.02 | 24.92 | 51.55 | 34.65 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 75.02 | 66.69 | 58.32 | 67.38 |
| Potash | $K_2O$ | 2.36 | 3.10 | 3.94 | 2.66 |
| Soda | $Na_2O$ | .46 | .25 | .78 | .59 |
| Lime | $CaO$ | .22 | .74 | .20 | .20 |
| Magnesia | $MgO$ | .66 | 1.13 | 1.28 | .83 |
| Manganese oxid | $MnO$ | .48 | .14 | .10 | .13 |
| Ferric oxid. | $Fe_2O_3$ | 3.80 | 8.84 | 8.00 | 6.10 |
| Alumina | $Al_2O_3$ | 12.73 | 14.07 | 20.35 | 14.17 |
| Phosphoric acid | $P_2O_5$ | .11 | .11 | .15 | .13 |
| Sulfuric acid | $SO_3$ | .07 | .10 | .09 | .07 |
| Carbonic acid | $CO_2$ | .11 | .14 | .10 | .09 |
| Water | $H_2O$ | .84 | 1.36 | 2.38 | 1.94 |
| Volatile | | 3.58 | 3.62 | 4.52 | 5.68 |
| | | 100.50 | 100.29 | 100.26 | 99.97 |

## GRASS SOILS.

*Triassic Formation.*—This formation enters the State from the north in a wide belt extending from Emmitsburg on the west to the Pennsylvania Railroad on the east above Taneytown. From Thurmont and Union Bridge it extends southwest along the foot of the Catoctin Mountains in a constantly narrowing strip until it reaches the mouth of the Monocacy. From this point it extends south of the Metropolitan Branch Railroad along Senica Creek, and forms the strong lands around Poolsville and Dawsonsville. These soils are little inferior in productiveness to the soils of the Trenton limestone, though they are not so certain in results, being apparently more affected by drought. These soils cover a considerable

area and with the limestone regions probably constitute the strongest agricultural soils of the State. They contain about 30 per cent. of clay, 5 per cent. of organic matter, and 60 per cent. of silica. In one acre to a depth of one foot there are from 81,000 to 115,000 pounds of potash, 4,800 to 20,000 pounds of lime, and 3,000 to 4,900 pounds of phosphoric acid.

TABLE XII.

*Mechanical and Chemical Analyses of Grass Soils of Triassic Formation.*

| Conventional Name. | Diameter, m. m. | 282 Type Sample, Md. | 949 Thurmont, Md. | 1082 Uniontown, Md. |
|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | |
| | | per cent | per cent | per cent |
| Gravel | 2–1 | .00 | .08 | .14 |
| Coarse sand | 1–.5 | .23 | .14 | .44 |
| Medium sand | .5–.25 | 1.29 | .75 | 1.97 |
| Fine sand | .25–.1 | 4.02 | 1.81 | 10.13 |
| Very fine sand | .1–.05 | 11.57 | 11.00 | 18.57 |
| Silt | .05–.01 | 38.97 | 35.12 | 30.49 |
| Fine Silt | .01–.005 | 8.84 | 9.62 | 8.51 |
| Clay | .005–.0001 | 32.70 | 34.18 | 22.27 |
| ULTIMATE CHEMICAL ANALYSES. | | | | |
| Silica | $SiO_2$ | 61.70 | 56.60 | 67.70 |
| Potash | $K_2O$ | 2.70 | 3.52 | 2.82 |
| Soda | $Na_2O$ | .68 | .76 | .42 |
| Lime | CaO | .66 | .40 | .16 |
| Magnesia | MgO | 1.40 | 3.29 | 1.54 |
| Manganese oxid | MnO | .17 | .06 | .08 |
| Ferric oxid | $Fe_2O_3$ | 6.16 | 6.00 | 5.70 |
| Alumina | $Al_2O_3$ | 19.22 | 22.67 | 15.97 |
| Phosphoric acid | $P_2O_5$ | .10 | .11 | .13 |
| Sulfuric acid | $SO_3$ | .23 | .12 | .10 |
| Carbonic acid | $CO_2$ | .07 | .13 | .09 |
| Water | $H_2O$ | 1.36 | 1.32 | 1.44 |
| Volatile | | 5.08 | 5.00 | 4.10 |
| | | 99.53 | 99.98 | 100.25 |

*Trenton Limestone Formation.*—This constitutes the soil of the Frederick and Hagerstown valleys. The Frederick Valley soils begin at LeGore, on the Pennsylvania Railroad, extend southwest widening until they reach their greatest width (about six miles) at Frederick, below which they narrow until the Potomac is crossed near the mouth of the Tuscarora Creek. This formation constitutes the finest type of farming land in the State, being thoroughly suited to the raising of large crops of grain and grass. These soils contain about 45 per cent. of clay, 6 per cent of organic matter, and 60 per cent. of silica. In one acre to a depth of one foot there are from 57,000 to 117,000 pounds of potash, 5,000 to 29,000 pounds of lime, and 2,700 to 6,600 pounds of phosphoric acid.

TABLE XIII.

*Mechanical and Chemical Analyses of Grass Soils of the Trenton Limestone Formation.*

| Conventional Name. | Diameter m. m. | 929 Hagerstown, 4 mi. S., Md. | 2734 Hagerstown, 5 mi. E., Md. | 2748 Leitersburg, 3 mi. S., Md. | 2751 Cavetown, 1½ mi. W., Md. | 2759 Hagerstown 2½ mi. W., Md. | 3888 | 3918 | 933 Sharpsburg, Md. |
|---|---|---|---|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | | | | | |
| | | per cent | per cent | per cent | per cent | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | 1.18 | 3.17 | .57 | .28 | 1.57 | | | .17 |
| Coarse sand | 1–.5 | .95 | 3.89 | .84 | .63 | 1.77 | | | .00 |
| Medium sand | .5–.25 | 1.56 | 3.66 | 1.14 | 1.46 | 1.53 | | | .15 |
| Fine sand | .25–.1 | 2.80 | 5.64 | 2.25 | 3.78 | 1.77 | | | .25 |
| Very fine sand | .1–.05 | 18.94 | 16.96 | 24.16 | 17.31 | 9.95 | | | 2.34 |
| Silt | .05–.01 | 40.72 | 29.27 | 31.89 | 31.25 | 24.49 | | | 19.04 |
| Fine silt | .01–.005 | 8.40 | 7.15 | 9.63 | 9.26 | 9.59 | | | 20.88 |
| Clay | .005–.0001 | 19.29 | 24.05 | 24.38 | 30.60 | 43.17 | | | 51.77 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | | | | | |
| Silica | $SiO_2$ | 79.08 | 67.21 | 67.59 | 67.94 | 64.53 | 59.66 | 45.14 | 47.24 |
| Potash | $K_2O$ | 1.91 | 4.32 | 3.68 | 3.08 | 2.64 | 2.30 | 2.64 | 4.41 |
| Soda | $Na_2O$ | .71 | .20 | .33 | .21 | .61 | .29 | .43 | .29 |
| Lime | $CaO$ | .75 | .64 | .44 | .43 | .45 | .98 | .60 | .18 |
| Magnesia | $MgO$ | .36 | .92 | .68 | 1.56 | .71 | 1.28 | 6.08 | .38 |
| Manganese oxid | $MnO$ | .13 | .12 | .12 | .09 | .25 | .35 | .08 | ...... |
| Ferric oxid | $Fe_2O_3$ | 3.62 | 6.58 | 4.88 | 4.90 | 7.41 | 5.83 | 11.40 | 7.76 |
| Alumina | $Al_2O_3$ | 8.72 | 14.13 | 16.19 | 15.39 | 14.98 | 17.40 | 21.18 | 26.17 |
| Phosphoric acid | $P_2O_5$ | .10 | .19 | .09 | .11 | .11 | .10 | .22 | .14 |
| Sulfuric acid | $SO_3$ | .13 | .10 | .07 | .10 | .10 | .13 | .10 | ...... |
| Carbonic acid | $CO_2$ | .18 | .11 | .07 | .05 | .12 | .52 | .13 | ...... |
| Water | $H_2O$ | 1.09 | 1.19 | 2.26 | 1.62 | 2.20 | 2.22 | 1.21 | ...... |
| Volatile | | 4.17 | 4.21 | 3.90 | 4.61 | 6.39 | 9.16 | 10.99 | 12.70 |
| | | 100.63 | 99.92 | 100.26 | 99.83 | 100.50 | 100.22 | 100.20 | 99.27 |

## MOUNTAIN FRUIT SOILS.

*Cambrian Sandstone.*—This includes several formations constituting the eastern and western slopes of South Mountain. There are also smaller areas on Catoctin and Sugar-Loaf mountains. The soils are characterized by being very stony, which, with their steepness, renders them unsuited to the growth of cultivated crops. The northwest slopes of these mountains have become famous as a peach-producing region. Peach growing has not been so successful on the south and east slopes of this formation, as the crop is more apt to be injured by frosts. The importance and rapid growth of the fruit industry warrants a separate and more detailed study of these soils than can be given in this general bulletin, and it is hoped to devote later to these soils the attention commensurate with their economic importance.

These soils contain about 20 per cent. of clay, 5 per cent. of organic matter, and 65 per cent. of silica. In one acre to a depth of one foot there are from 81,000 to 160,000 pounds of potash, 15,000 to 24,000 pounds of lime, and 2,100 to 4,500 pounds of phosphoric acid.

TABLE XIV.

*Mechanical and chemical analyses of Fruit Soils of the Cambrian Sandstone Formation.*

| Conventional Name. | Diamiter, m. m. | 943 Smithsburg, Md. | 2744 Caretown, 1 mi. N. E., Md. | 3916 Crampton's Gap west of Md. | 3893 Harpers Ferry, 2 mi. N. Md |
|---|---|---|---|---|---|
| MECHANICAL ANALYSES. | | | | | |
| | | per cent | per cent | per cent | per cent |
| Gravel | 2–1 | 2.54 | 4.69 | | |
| Coarse sand | 1–.5 | 2.99 | 3.39 | | |
| Medium sand. | .5–.25 | 3.43 | 3.54 | | |
| Fine sand | .25–.1 | 5.04 | 6.50 | | |
| Very fine sand | .1–.05 | 16.72 | 18.36 | | |
| Silt | .05–.01 | 39.34 | 28.09 | | |
| Fine silt | .01–.005 | 8.58 | 10.59 | | |
| Clay | .005–.0001 | 13.02 | 18.86 | | |
| ULTIMATE CHEMICAL ANALYSES. | | | | | |
| Silica | $SiO_2$ | 68.10 | 70.44 | 62.20 | 56.84 |
| Potash | $K_2O$ | 2.72 | 2.89 | 3.92 | 4.08 |
| Soda | $Na_2O$ | .21 | .70 | .27 | .75 |
| Lime | CaO | .51 | .78 | .82 | .38 |
| Magnesia | MgO | 1.04 | .69 | 1.06 | .85 |
| Manganese oxid | MnO | .12 | .00 | .13 | .18 |
| Ferric oxid | $Fe_2O_3$ | 3.55 | 3.18 | 8.20 | 7.38 |
| Alumina | $Al_2O_3$ | 16.06 | 14.64 | 16.81 | 22.32 |
| Phosphoric acid | $P_2O_5$ | .15 | .08 | .07 | .15 |
| Sulfuric acid | $SO_3$ | .12 | .11 | .07 | .08 |
| Carbonic acid | $CO_2$ | .11 | .09 | .09 | .09 |
| Water | $H_2O$ | 1.23 | 1.00 | 1.20 | 1.12 |
| Volative | | 5.95 | 4.82 | 5.36 | 5.67 |
| | | 99.87 | 99.66 | 100.17 | 99.89 |

## BARREN LAND.

Within the States there are several distinct classes of barren land.

*Lafayette Pine Barrens.*—This formation constitutes large bodies of barren land in Southern Maryland. These lands occupy the higher ground in the interior of the river necks. They are the sands of the Neocene age and accompany the Chesapeake formation. These soils are not lighter in texture than many good truck soils of the State, but they are rather different in chemical composition.

*Serpentine Formation.*—This formation is another class of barren soils. They occur in Harford County, and are locally known as the "Bare Hills." Smaller areas occur throughout Carroll, Howard, Baltimore and Montgomery counties. The cause of the poverty of these soils is not clearly apparent from the mechanical or chemical analysis. It is generally regarded as being due to the large amount of magnesia that is present. These soils contain about 20 per cent. of clay, 5 per cent. of organic matter, and 70 per cent. of silica. In one acre to a depth of one foot there are from 40,000 to 55,000 pounds of potash, 9,000 to 25,000 pounds of lime, and 2,280 to 5,400 pounds of phosphoric acid.

*Potomac Clay.*—This formation occupies the high ground in a wide belt across the State from Washington to Baltimore and northeastward. It is quite easily distinguished and has about the same mechanical composition as the heavy soils of the State, but the structure and imperviousness to water renders it of little or no agricultural value. This formation has about 45 per cent. of clay, 6 per cent. of organic matter, and 65 per cent. of silica. In one acre to a depth of one foot it contains from 33,000 to 49,000 pounds of potash, 3,000 to 22,000 pounds of lime, and 3,000 to 6,000 pounds of phosphoric acid.

TABLE XV.

*Mechanical and Chenical analyses of Barren Lands.*

| Conventional Name. | Diameter, m. m. | LAFAYETTE. | SERPENTINE. | | POTOMAC CLAYS. | | |
|---|---|---|---|---|---|---|---|
| | | 209 | 3033 | 3873 | 305 | 2185 | 592 |
| | | Cove Point, Md. | Chro . e Hill, Md. | Bare Hills, Md. | Baltimore, Md. | Takoma Park, Md. | |
| MECHANICAL ANALYSES. | | | | | | | |
| | | % | % | % | % | % | % |
| Gravel | 2–1 | .51 | 1.35 | | .31 | .00 | .16 |
| Coarse sand | 1–.5 | 1.32 | 1.54 | | .82 | .18 | .50 |
| Medium sand | .5–.25 | 17.84 | 1.85 | | 2.69 | .14 | 1.42 |
| Fine sand | .25–.1 | 55.82 | 2.89 | | 3.23 | .28 | 1.76 |
| Very fine sand | .1–.05 | 16.75 | 18.52 | | 8.89 | 20.85 | 14.87 |
| Silt | .05–.01 | 3.08 | 39.48 | | 26.17 | 28.55 | 27.36 |
| Fine silt | .01–.005 | .09 | 9.34 | | 11.18 | 7.12 | 9.15 |
| Clay | .005–.0001 | 3.74 | 20.85 | | 42.36 | 33.41 | 37.89 |
| ULTIMATE CHEMICAL ANALYSES. | | | | | | | |
| Silica | $SiO_2$ | 94.32 | 69.40 | 65.68 | 62.64 | 63.24 | 66.89 |
| Potash | $K_2O$ | .12 | 1.44 | 1.84 | 1.96 | 1.12 | 1.31 |
| Soda | $Na_2O$ | .11 | .61 | 3.12 | .40 | .85 | .49 |
| Lime | CaO | .04 | .30 | .84 | .46 | .75 | .10 |
| Magnesia | MgO | .07 | 2.33 | 4.08 | .38 | .38 | .02 |
| Manganese oxid | MnO | .... | .20 | .15 | .12 | .06 | ...... |
| Ferric oxid | $Fe_2O_3$ | 1.25 | 7.04 | 2.60 | 6.04 | 2.40 | 8.77 |
| Alumina | $Al_2O_3$ | 2.66 | 11.64 | 15.28 | 20.82 | 22.43 | 16.50 |
| Phosphoric acid | $P_2O_5$ | .02 | .08 | .18 | .10 | .17 | .21 |
| Sulfuric acid | $SO_3$ | ...... | .08 | .06 | .11 | .08 | ...... |
| Carbonic acid | $CO_2$ | ...... | .09 | .07 | .14 | .15 | ...... |
| Water | $H_2O$ | ...... | 1.28 | .82 | .64 | .86 | ...... |
| Volatile | | 1.21 | 4.76 | 4.94 | 6.20 | 7.70 | 5.84 |
| | | 99.80 | 99.41 | 99.66 | 100.00 | 100.16 | 100.13 |

Considerable variation is noticeable both in the physical and chemical composition of any given formation; this is not so great from the physical as from the chemical standpoint where the variation of the important elements of plant food within a given formation is often as great as the difference between the lightest and the heaviest formations. Hence it is evident that it is utterly impossible to distinguish these soils by this method of analysis. Potash seems to be the important plant food in which the formations differ most, the percentage being greatest in the soils derived from the Trenton and Helderburg limestones, Cambrian and Triassic sandstones, and the Catskill and Hudson River shales. About as much lime seems to be present in the lightest soils as in the heaviest, it is low in all cases and particularly low in the heavier soils. Phosphoric acid varies considerably and is in all cases rather low. This conclusion agrees with the farming experience of the people throughout the State. The wheat soils of the middle west average about 0.35 per cent. of phosphoric acid soluble in strong hydrochloric acid; our best wheat soils average only 0.15 per cent. of total phosphoric acid. The noticeably high percentage of phosphoric acid of the Chesapeake soils is probably due to the marls which are associated with this formation.

In the following tables are given the average chemical and physical composition of the formations:

## TABLE XVI.

*Average Ultimate Chemical Composition of the formation.*

| Conventional Name. | Formula. | Columbia Truck. | Chesapeake and Columbia Truck. | Chesapeake Tobacco. | Chesapeake Corn and Whea.. | Columbia Corn and Wheat. | Chesapeake and Columbia Corn and Wheat. | Hudson River Shale. | Gneiss. | Gabbro. | Helderberg Limestone. | Catskill Sandstone. | Triassic Sandstone. | Trenton Limestone. | Cambrian Sandstone. | Lafayette Sands. | Serpentine. | Patomac Clay. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| Silica ......... | $SiO_2$ | 93.89 | 89.92 | 84.95 | 78.05 | 80.99 | 78.68 | 64.80 | 64.67 | 53.54 | 70.86 | 65.85 | 62.00 | 65.25 | 64.41 | 94.32 | 67.55 | 62.94 |
| Potash.. ...... | $K_2O$ | .47 | 1.06 | .91 | 1.27 | 1.29 | 1.57 | 2.40 | 1.31 | .90 | 2.37 | 3.02 | 3.10 | 3.05 | 3.40 | .12 | 1.64 | 1.54 |
| Soda.. ......... | $Na_2O$ | .22 | .94 | .61 | .52 | .51 | .77 | .44 | .46 | .80 | .51 | .52 | .62 | .42 | .48 | .11 | 1.87 | .63 |
| Lime ......... | $CaO$ | .41 | .42 | .53 | .51 | .60 | .47 | .81 | .38 | .53 | .55 | .34 | .53 | .57 | .62 | .04 | .57 | .61 |
| Magnesia.... | $MgO$ | .32 | .40 | .47 | .73 | .28 | .58 | 1.09 | .56 | .86 | .89 | .98 | 2.08 | .85 | 1.21 | .07 | 3.21 | .38 |
| Oxid of Manganese | $MnO$ | .08 | .08 | .13 | .08 | .12 | .13 | .21 | .10 | .00 | .20 | .21 | .10 | .13 | .11 | ...... | .18 | .09 |
| Ferric oxid. | $Fe_2O_3$ | .75 | .75 | 2.30 | 3.26 | 2.67 | 2.56 | 5.70 | 6.83 | 8.41 | 5.02 | 6.69 | 3.95 | 6.47 | 5.58 | 1.25 | 4.82 | 4.22 |
| Alumina.... | $Al_2O_3$ | 1.90 | 4.64 | 6.58 | 9.98 | 8.82 | 10.77 | 15.50 | 17.32 | 23.90 | 12.57 | 15.35 | 19.29 | 15.10 | 17.46 | 2.66 | 13.46 | 21.63 |
| Phosphoric acid...... ... | $P_2O_5$ | .07 | .075 | .25 | .20 | .16 | .056 | .11 | .083 | .08 | .17 | .125 | .11 | .15 | .14 | .02 | .19 | .135 |
| Sulphuric acid.......... | $So_3$ | .10 | .04 | .12 | .08 | .07 | .10 | .14 | .17 | .09 | .09 | .08 | .15 | .10 | .10 | ...... | .07 | .10 |
| Carbonic acid.......... | $Co_2$ | .08 | .09 | .05 | .08 | .05 | .06 | .30 | .09 | .12 | .12 | .11 | .10 | .11 | .10 | ...... | .08 | .15 |
| Water........ | $H_2O$ | .19 | .29 | 1.29 | 1.70 | 1.28 | 1.10 | 1.79 | 1.97 | 2.23 | 1.33 | 1.63 | 1.37 | 1.60 | 1.14 | ...... | 1.05 | .75 |
| Volatile .... | | 1.00 | 1.57 | 2.32 | 3.64 | 3.26 | 3.19 | 6.86 | 6.08 | 8.55 | 5.36 | 4.35 | 4.73 | 5.70 | 5.28 | 1.21 | 4.85 | 6.95 |
| Total.... | | 99.48 | 100.25 | 100.51 | 100.00 | 100.10 | 100.54 | 100.15 | 100.00 | 100.01 | 100.04 | 99.25 | 100.13 | 99.50 | 100.03 | 99 80 | 99.54 | 100.34 |

## TABLE XVII.

*Average Physical Composition of the Formation.*

| Conventional Name. | Diameter, m. m. | Columbia, Truck. | Chesapeake, and Columbia, Truck. | Chesapeake, Tobacco. | Chesapeake, Corn and Wheat. | Columbia, Corn and Wheat | Chesapeake and Columbia, Corn and Wheat. | Hudson River Shale. | Gneiss. | Gabbro. | Helderberg Limestone. | Catskill Sandstone. | Triassic Sandstone. | Trenton Limestone. | Cambrian Sandstone. | Lafayette Sands. | Serpentine. | Potomac Clay. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. m. | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| Gravel........ . ..... | 2–1 | .85 | 1.45 | .66 | .00 | .39 | .19 | 1.85 | 4.37 | .52 | .79 | 1.36 | .07 | 1.36 | 2.93 | .51 | 1.09 | .16 |
| Coarse sand......... | 1–.5 | 5.48 | 6.68 | 1.17 | .24 | 1.57 | 1.39 | 3.38 | 3.33 | .72 | 2.34 | 1.76 | .27 | 1.59 | 3.21 | 1.32 | 1.37 | .50 |
| Medium sand. ..... | .5–.25 | 35.78 | 33.12 | 4.71 | 2.62 | 6.64 | 8.39 | 6.08 | 3.09 | 1.05 | 2.77 | 2.09 | 1.34 | 1.82 | 4.60 | 17.84 | 1.67 | 1.42 |
| Fine sand ..... ..... | .25–.1 | 27.33 | 32.52 | 12.53 | 6.29 | 5.34 | 8.43 | 10.45 | 5.75 | 3.15 | 6.16 | 7.66 | 5.32 | 2.79 | 6.50 | 55.82 | 2.26 | 1.76 |
| Very fine sand..... | .1–.05 | 10.29 | 9.63 | 31.55 | 22.67 | 8.11 | 14.35 | 20.69 | 14.80 | 11.58 | 13.68 | 17.39 | 13.71 | 14.32 | 15.88 | 16.75 | 16.51 | 14.87 |
| Silt ................. .. | .05–.01 | 11.63 | 9.69 | 19.47 | 25.39 | 37.90 | 37.37 | 23.84 | 32.10 | 31.42 | 31.58 | 24.15 | 34.86 | 29.92 | 33.91 | 3.08 | 41.77 | 27.36 |
| Fine silt........ ..... | .01–.005 | 3.00 | 2.44 | 6.48 | 10.14 | 11.30 | 6.18 | 6.61 | 6.70 | 6.36 | 8.35 | 7.65 | 8.66 | 9.06 | 7.12 | .90 | 8.49 | 9.15 |
| Clay.................... | .005–.0001 | 4.05 | 2.78 | 15.18 | 29.76 | 24.84 | 15.95 | 21.56 | 24.67 | 32.42 | 28.31 | 32.54 | 29.72 | 31.26 | 18.64 | 3.74 | 21.37 | 37.89 |

### Results by the Concentrated Hydrochloric Acid Method.

Equal portions of the samples from a single geological formation were mixed to constitute a type sample the composition of which should represent that of the geological formation from which the samples were obtained. These type samples were then analyzed by the concentrated hydrochloric method with the following results:

TABLE XVIII.

*Showing the Amount of each Ingredient Soluble in 1.115 Sp. Gr. Hydrochloric Acid.*

| Conventional Name. | Insoluble Silicates | Potash | Soda | Lime | Magnesia | Oxide of Manganese | Ferric Oxide | Alumina | Phosphoric Acid | Sulphuric Acid | Carbonic Acid | Water | Volatile | Reaction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Formula. | | $K_2O$ | $Na_2O$ | $CaO$ | $MgO$ | $MnO$ | $Fe_2O_3$ | $Al_2O_3$ | $P_2O_5$ | $So_3$ | $Co_2$ | $H_2O$ | | |
| Potomac Clays. | % 84.05 | .14 | .10 | .07 | .04 | .02 | 3.07 | 5.26 | .046 | .07 | .15 | .75 | 6.95 | Very faintly acid. |
| Serpentine. | % 83.71 | .18 | .10 | .10 | .88 | .02 | 3.82 | 5.22 | .065 | .01 | .08 | 1.05 | 4.85 | Acid. |
| Cambrian Sandstone. | % 82.42 | .23 | .11 | .17 | .53 | .03 | 3.88 | 6.15 | .09 | .00 | .10 | 1.14 | 5.28 | Neutral. |
| Trenton Limestone. | % 74.49 | .45 | .08 | .29 | .85 | .08 | 4.18 | 10.92 | .102 | .05 | .11 | 1.60 | 5.70 | Neutral. |
| Triassic Sandstone. | % 74.81 | .67 | .37 | .41 | 1.78 | .05 | 5.05 | 9.62 | .082 | .07 | .10 | 1.37 | 4.73 | Acid |
| Catskill Sandstone. | % 81.76 | .57 | .17 | .13 | .43 | .05 | 4.30 | 6.87 | .055 | ..... | .11 | 1.63 | 4.35 | Neutral. |
| Helderberg Limestone. | % 80.00 | .72 | .24 | .30 | .58 | .12 | 4.30 | 6.97 | .105 | ..... | .12 | 1.33 | 5.36 | Neutral. |
| Gabbro. | % 61.79 | .19 | .12 | .18 | .34 | .02 | 8.40 | 17.36 | .08 | .05 | .12 | 2.23 | 8.55 | Neutral. |
| Gneiss | % 73.56 | .19 | .03 | .13 | .54 | .02 | 6.60 | 10.78 | .058 | .03 | .09 | 1.97 | 6.08 | Neutral. |
| Hudson River Shale. | % 73.46 | .40 | .22 | .51 | .78 | .03 | 4.15 | 10.85 | .11 | .05 | .30 | 1.79 | 6.86 | Alkaline. |
| Corn and Wheat soil of Eastern Shore. | % 86.56 | .13 | .07 | .14 | .45 | .02 | 1.88 | 6.00 | .034 | .05 | .06 | 1.10 | 3.19 | Neutral. |
| Columbia, Corn and Wheat | % 88.13 | .21 | .14 | .20 | .26 | .02 | 1.95 | 5.13 | .06 | .00 | .05 | 1.28 | 3.26 | Acid 3rd in Acidity. |
| Chesapeake, Corn and Wheat | % 84.08 | .42 | .18 | .09 | .52 | .02 | 1.85 | 7.15 | .17 | ..... | .08 | 1.70 | 3.64 | Most Acid of all. |
| Chesapeake, Tobacco. | % 89.72 | .25 | .10 | .12 | .37 | .03 | 2.12 | 3.78 | .155 | .03 | .05 | 1.29 | 2.32 | Acid 2d in Acidity. |
| Chesapeake and Columbia, Truck. | % 96.12 | .08 | .06 | .11 | .02 | .03 | .58 | 1.25 | .024 | ..... | .09 | .20 | 1.57 | Very faintly Acid. |
| Columbia, Truck. | % 96.92 | .025 | .04 | .04 | .21 | .01 | .75 | 1.90 | .025 | .01 | .08 | .19 | 1.00 | |

For comparison the analysis of some typical western soils are given in the following table. These analyses represent the composition of the soils with which the Maryland farmers have to compete in the production of staple crops. The average yield from these soils, under present conditions and without fertilizers, is somewhat higher than that of the best soils of our State. While it is not safe to draw the conclusion that our soils to be as productive as these western ones, must contain as much of the essential plant foods, a comparison of our soils with these strong soils is interesting and suggestive.

## TABLE XIX.

*Showing the amount of each Ingredient soluble in 1.115 Sp. Gr. Hydrochloric Acid.*

| Conventional Name. | Formula. | Minnesota Subsoils. | | | | | | Michigan Wheat Soils. | | | Washington Subsoil. | Tennessee Subsoil. | India.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cultivated 25 years. | Virgin. 38 % clay. No coarse particles. | Wheat 16 years. No coarse particles. | Wheat and Barley 22 yrs. More sand than average prairie. 22 % clay. | Corn 20 years. Very Sandy Loam. | Cultivated 25 years. 38 % Clay. | Cultivated 40 years. | Cultivated 30 years. | Bottom Land. | Virgin Similar soils Cultivated 15 years Show no deterioration. | Trenton Limestone Cultivated 75 to 100 yrs No fertilizer | Cultivated 2000 years without manure. Subsoil. |
| | | % | % | % | % | % | % | % | % | % | % | % | % |
| Insoluble Matter. | | 79.96 | 75.01 | 88.26 | 85.47 | 93.25 | 75.72 | 58.17 | 75.74 | 67.20 | 86.79 | 85.53 | 67.01 |
| Potash ......... ...... | $K_2O$ | .36 | .37 | .29 | .25 | .23 | .35 | 1.84 | 1.10 | 1.85 | .64 | .44 | .50 |
| Soda.......... ........ | $Na_2O$ | .11 | .29 | .20 | .09 | .35 | .13 | 1.20 | .43 | 1.15 | .37 | .18 | .01 |
| Lime......... ......... | $CaO$ | 2.28 | 2.81 | .84 | 2.14 | .36 | .23 | 1.98 | 1.38 | 1.64 | 1.00 | .40 | 1.76 |
| Magnesia ............ | $MgO$ | .39 | .17 | .32 | .20 | .17 | .19 | 1.43 | .56 | 1.23 | .73 | .33 | 2.19 |
| Ferric Oxid ......... | $Fe_2O_3$ | 3.13 | 1.83 | 2.58 | 2.56 | 1.83 | 4.15 | 7.62 | 5.46 | 7.91 | 4.55 | 2.28 | 11.50 |
| Alumina ............ | $Al_2O_3$ | 2.27 | 7.10 | 4.20 | 2.63 | 1.93 | 7.34 | 6.48 | 4.20 | 6.31 | 7.53 | 4.23 | 10.41 |
| Phosphoric Acid.. | $P_2O_5$ | .27 | .21 | .19 | .11 | .20 | .11 | .40 | .33 | .49 | .14 | .14 | .05 |
| Sulphuric Acid.... | $SO_3$ | .06 | .02 | .09 | 0.09 | .13 | .03 | .32 | .18 | .30 | ..... | .03 | .00 |
| Carbonic Acid...... | $CO_2$ | 2.00 | 2.16 | .02 | 2.50 | .01 | .16 | ...... | ..... | ...... | .02 | ...... | .53 |
| Total Volatile ..... | | 5.63 | 7.98 | 3.76 | 2.56 | 2.00 | 7.02 | 10.97 | 7.50 | 7.48 | 3.61 | 4.22 | 5.79 |

*This sample represents the black cotton soils, or Regur, of India Presumably they have never been fertilized, but are regarded as still extremely fertile. They have the power of retaining moisture to a remarkable degree. They are almost exclusively planted to cotton. The soil from which the sample came has averaged 10 bushels of wheat for twelve years.

In attempting to interpret the results of the chemical examination of soils there are so many other factors that affect and modify conclusions that the establishment of a minimum standard for the amount of any essential ingredient that must be present in an available condition, for the economic production of crops, becomes a very difficult problem. Hilgard*, as the result of a great deal of work on the soils of the South and West, gives the following figures which represent the amounts of the several essential ingredients, soluble in strong hydrochloric acid, that soils of various character should contain.

| | | |
|---|---|---|
| *Potash:* | In sandy soils of great depth may be less than | 0.1% |
| | In sandy loams | 0.3 to 0.1 % |
| | In loams | 0.45 to 0.3 % |
| | In heavy clays and clay loams | 0.80 to 0.45% |
| *Lime:* | In lightest sandy soils not less than | 0.1 % |
| | In clay loams not less than | 0.25% |
| | In heavy clay soils not less than | 0.50% |
| | No advantage in having more than | 2.00% |
| *Phosphoric Acid:* | Seriously deficient in virgin soils when less than unless accompanied by a large amount of lime | 0.05% |
| | Sandy loams with fair supply of lime | 0.1 % |
| | Sandy loams with poor supply of lime | 0.2 % |
| | Clayey soils not less than | 0.2 % |

*Report of the California Agricultural Experiment Station, 1888–89, pp 163 et seq.

*Organic Matter.*—The organic matter of the soil is very complex, consisting as it may of any or all compounds resulting from decay. While we are unable to state the amounts of organic matter most beneficial to the various kinds of soils, yet considerable importance must be ascribed to its presence in the soil. It varies greatly—in the light sandy soils of southern and eastern Maryland it may be less than 1 per cent., while in the heavier soils of western and northern Maryland it may rise to 8 or 10 per cent., and in humus soils it is frequently as high as 70 per cent.

Many years ago efforts were made to separate definite organic bodies from the organic matter of the soil, and Mulder—by successive treatments with dilute acids and alkalies, separated humus, humates, ulmates, etc., to which he assigned definite chemical formulae. Later investigation has not borne out his results regarding definite formulae for these decaying bodies, and we must content ourselves with a very general consideration of this constituent of soils. Decaying organic matter, however, containing as it does all the elements of plant food, must furnish these elements in a more or less available form to vegetation and undoubtedly acts chemically upon the soil, rendering its constituents more soluble and available. It also acts physically, increasing the power of the soil to hold moisture, heat, and air and making it easier to till. Certain it is that generally in soils of the same character the productiveness increases approximately with the increase of organic matter.

The first thing to attract our attention, in the above statement of the amounts of the essential elements required to render various soils fertile, is that the finer the texture of a soil the more soluble matter it must contain. In other words, before attempting to draw conclusions from a chemical analysis we must know the physical condition of the soil. The explanation of the fact that a fine-textured soil to be fertile must contain more soluble plant food than a coarse-textured one is probably found in the well-known physical power of soils to remove dissolved matter from its solutions. This power is proportional to the surface; that is, it is greater the finer the texture of the soil.

It may be said, in passing, that a consideration of these facts shows us that "soluble" plant food is not necessarily "available" plant food.

For comparson with very fertile soils the standards of Hilgard may be supplemented by a statement of the maximum and minimum percentages of the essential constituents contained in some unfertilized subsoils of the West, analyses of which are given on page 50.

| | | | |
|---|---|---|---|
| Potash | 0.23 to 1.85 | per | cent, |
| Lime | 0.23 to 2.81 | " | " |
| Magnesia | 0.17 to 1.23 | " | " |
| Phosphoric acid | 0.11 to 0.49 | " | " |
| Organic matter | 2.00 to 11.00 | " | " |

The value of these figures is somewhat lowered by ignorance of the physical conditions of the soils, a mechanical analysis being available in but few instances. There is a great difference in the amounts of the essential elements present in these strong soils, but the main point to be borne in mind is that the minimum of one element is seldom associated with the minimum of another and never with the minimum of all.

Upon comparing our results with the conclusions of Hilgard; with productive, unfertilized soils of other States; and with one another, some very interesting points are noticeable. Judged by Hilgard's standards the Columbia, Gneiss, Serpentine, Gabbro, and Potomac clays are deficient in potash. Compared with the strong western soils the amounts of potash removed from our heaviest and best soils are considerably above the minimum; those that are below are the Columbia, Gneiss, Serpentine, and Potomac clays, or the same soils that are below the Hilgard standard. The total amount of potash contained even in the poorer soils is so large as to suggest that it may be well worth the effort to render some of the reserve store available, rather than to apply potassic manures indiscriminately.

Concerning the conclusions to be drawn from the agricultural practice throughout the State it may be said that, in general, they support the conclusions based upon the analyses.

As the problem of potash fertilization, like that of phosphoric acid, is greatly affected by other readily soluble soil compounds—notably by lime and organic matter—there may be some doubt as to whether the Gneiss, Serpentine, Gabbro, and Potomac clays are really deficient in potash. The consideration of this point will be taken up later.

All the formations, with the possible exception of the Columbia truck of the Eastern Shore and the Hudson River shales, must be regarded as seriously deficient in available lime. This conclusion, based on Hilgard's figures, is emphasized by a comparison with the unfertilized soils where

the lime soluble in strong hydrochloric acid is in the majority of instances more than one half of one per cent.

Practical farm experience strongly supports the conclusion deduced from the chemical analyses, and the general statement may be made that, when applied under proper conditions, lime is seldom without benefit on any Maryland soil.

Attention has been called to the fact that even in the best of our soils the total amount of phosphoric acid is small. In the majority of the formations more than fifty per cent present is soluble in strong hydrochloric acid, being from 0.17 per cent. in the Chesapeake wheat soils to 0.024 per cent in the Columbia truck of the Eastern Shore; but five of the seventeen formations contain more than 0.1 per cent soluble in strong acid. Judged by Hilgard's standards all these soils are low in phosphoric acid—when compared with the strong western soils they are markedly low. The deficiency is more accentuated in the majority of cases by a low lime content. These conclusions are in harmony with farm experience all over the State; namely, larger returns are realized from an application of phosphoric acid than from applications of nitrates or potash salts.

Organic matter with water of combination constitutes the "volatile matter" as here reported. In the Gabbro and the Potomac clays considerable water of combination, that is water chemically combined with the soil components, may be present, but in the other cases it is probable that nearly all of the volatile matter is organic. As is to be expected, the heavier, finer-textured soils contain much more organic matter than the so-called light or sandy soils. This is due to the greater natural fertility of these soils and to a slower oxidation of their organic matter. The data on these soils at our command are not sufficient to warrant any very definite statements regarding the effects of organic matter in the different formations; but it may be said that in view of its well-known chemical and physical action upon the soil, and the additional fact that it carries considerable plant food in a comparatively easily available condition, we may expect greater fertility to accompany a larger supply of organic matter.

It may be said that the conclusions drawn from the results by this method, using the accepted standard of comparison, are generally in harmony with the conclusions to be drawn from crop production. Comparison of the analyses of these soils with the analyses of fertile soils (for this is what the use of these standards amounts to), and with their crop holds shows our soils to be markedly deficient in lime, deficient in phoshporic acid to a less degree and, in nearly all cases, well supplied with potash.

### The Fifth Normal Hydrochloric Acid Method.

The results by this method possess particular interest because they are expected to show the present comparative fertility of the several formation . Attention has been called to the fact that the amounts of the various essential plant foods dissolved by this method are usually much more than needed bo crops, so that the results, like those of the strong hydrochloric acid method, are simply comparative.

The analyses of the type samples are given in the following table :

# TABLE XX.

*Showing the amount of each Ingredient Soluble in $\frac{N}{5}$ Hydrochloric Acid.*

| Conventional Name. | Formula. | Columbia, Truck, Southern Maryland. | Chesapeake and Columbia, Truck, Eastern Shore | Chesapeake, Tobacco. | Chesapeake, Corn and Wheat. | Columbia, Corn and Wheat. | Corn and Wheat soils of the Eastern Shore. | Hudson River Shale. | Gneiss. | Gabbro. | Helderberg Limestone. | Catskill Sandstone. | Triassic Sandstone. | Trenton Limestone. | Cambrian Sandstone. | Serpentine. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| Insoluble.... | | 98.56 | 97.80 | 95.47 | 93.54 | 95.14 | 95.00 | 89.87 | 91.12 | 88.34 | 92.41 | 92.03 | 93.15 | 92.59 | 93.02 | 93.80 |
| Silica, Soluble in the acid... | $SiO_2$ | .015 | .0133 | .0614 | .150 | .0563 | .1143 | .1700 | .1267 | .1671 | .0760 | .1279 | .1143 | .1206 | .0640 | .1087 |
| Potash........ | $K_2O$ | .0104 | .0088 | .0146 | Lost | .0062 | .0240 | .0162 | .0110 | .0130 | .0220 | .0172 | .0150 | .0116 | .0164 | .0154 |
| Soda......... | $Na_2O$ | .0116 | .0090 | .0094 | Lost | .0092 | .0142 | 0002 | .118 | .0094 | .0060 | .0098 | .0096 | .0108 | .0078 | .0175 |
| Lime......... | CaO | .022 | .087 | .098 | .09 | .109 | .094 | .4773 | .1170 | .074 | .255 | .046 | .103 | .267 | .0717 | .0427 |
| Magnesia.... | MgO | .007 | .0193 | .030 | .056 | .0283 | .041 | .0666 | .0577 | .050 | .0570 | .030 | .053 | .058 | .0275 | .050 |
| Manganese oxid......... | MnO | ...... | ...... | ...... | ..... | ...... | ...... | Not determined. | | | ...... | ...... | ...... | ...... | ..... | ...... |
| Ferrid oxid and Alumina.... | $Fe_2O_3$ and $Al_2O_3$ | .114 | .115 | .617 | .711 | .205 | .364 | .438 | .378 | .455 | .384 | .466 | .36 | .385 | .280 | .480 |
| Phosphoric acid......... | $P_2O_5$ | .001 | .0013 | .044 | .0311 | .0042 | .0022 | .0015 | .0010 | .0008 | .0029 | .0017 | .0024 | .0023 | .0024 | .0005 |

The amount of potash dissolved is from 0.0062 per cent from the corn and wheat soils of the Eastern Shore to 0.024 per cent in the Columbia corn and wheat soils of southern Maryland. These percentages are equal to about 190 and 700 pounds, respectively, in an acre to the depth of one foot. The amount of potash soluble in this dilute acid in one acre one foot deep is about as follows:

TABLE XXI.

| | Pounds. |
|---|---|
| Columbia, truck—southern Maryland | 300 |
| " " Eastern Shore | 250 |
| Chesapeake, tobacco | 425 |
| " corn, wheat | 300 |
| Columbia—corn, wheat, southern Maryland | 190 |
| " " " Eastern Shore | 700 |
| Hudson River shale | 475 |
| Gneiss | 325 |
| Gabbro | 400 |
| Helderberg limestone | 650 |
| Catskill sandstone | 510 |
| Triassic sandstone | 450 |
| Trenton limestone | 350 |
| Cambrian sandstone | 480 |
| Serpentine | 460 |

From the crop history of the soils and these figures, what conclusions can we draw as to the supply of potash in the several formations? It has been stated that general practical experience shows under present conditions the various truck soils and the Columbia corn and wheat soils of southern Maryland are benefitted by application of potash. It is problematical whether the productiveness of the Gneiss, Gabbro, Serpentine, and Potomac clays is economically increased by application of potash. It is safe to say that in general no economic benefit follows the use of potash on the other formations. If we regard the truck and the Columbia corn and wheat soils of southern Maryland as the only soils deficient in potash, we must conclude that when a soil shows less than 300 pounds of potash per acre foot soluble in fifth normal acid, it needs potash: if we regard as deficient the Gneiss, Gabbro, Serpentine, and Potomac clays, we must say that soils showing by this method less than 460 pounds of soluble potash, need potash. This would include also the Triassic sandstone, Trenton limestone, Chesapeake wheat and Chesapeake tobacco; all of which are certainly capable, under proper conditions, of supplying all the potash needed by ordinary crops. The conclusion is forced upon us that so far as potash is concerned the method shows nothing definitely that has not been shown by the strong hydrochloric acid method and by experience. It presents additional, though not strong evidence, that all soils of the State (except the truck and the Columbia corn and wheat) are well supplied with potash.

In only three cases is the amount of lime dissolved appreciably over 0.1 per cent. These are the Trenton limestone with 0.267 per cent., Helderberg limestone with 0.255 per cent., and Hudson River shales with 0.477 per cent.—these rank first, third and eighth, respectively.

The following table shows the amounts of lime in pounds per acre foot dissolved from the several formations by the fifth normal hydrochloric acid:

TABLE XXII.

| | | Pounds. |
|---|---|---|
| Trenton limestone | about | 9,300 |
| Triassic sandstone | " | 3,400 |
| Helderberg limestone | " | 9,000 |
| Gabbro | " | 2,600 |
| Gneiss | " | 4,100 |
| Chesapeake—corn, wheat | " | 3,100 |
| Columbia | " | 3,500 |
| Corn and wheat soils, Eastern Shore | " | 3,300 |
| Catskill | " | 1,600 |
| Hudson River shales | " | 17,000 |
| Chesapeake tobacco | " | 3,400 |
| Cambrian. | " | 2,500 |
| Serpentine | " | 1,400 |
| Columbia truck, southern Maryland | " | 800 |
| Truck soils, Eastern Shore | " | 3,000 |

As but little work has been done upon the solubility in dilute acids of the lime compounds of the soil no standards have been established with which to compare these results. It is a fact demonstrated by the experience of farmers all over the State that all Maryland soils are benefitted to a greater or less degree by liming, and in general it may be said that in its chemical effect the most benefit is to be expected from its application to those soils showing the least soluble lime. However, as the effect of lime is largely through its physical action it is not safe to advance as a final conclusion that its use will necessarily yield the most decisive results on such soils. For example, the application of lime is very beneficial to the Trenton limestone and to the Triassic sandstone soils, which contain more lime soluble in weak acid than the other soils—except the Hudson River shales. Whether or not lime is relatively as beneficial to these soils as to those containing less soluble lime is an open question which, considering the general deficiency, is not of much practical importance. Owing to the many-sided action of lime, it does not seem advisable to draw conclusions as to the relative effect that applications of lime would exert upon soils of different formations, yet from a careful consideration of all the conditions the conclusion seems warranted that the Chesapeake and the Columbia soils of southern Maryland are the soils that would be most improved. Large quantities of soluble potash (except in the Columbia) and, as will be seen later, of phosphoric acid are present in these soils, while lime is relatively deficient. These soils are peculiar in Maryland in so far as many of them have been cultivated from the settlement of the State to the present time without fertilizing them, but they now show the need of lime. Crops like clover, requiring large amounts of lime, can not be grown as successfully as formerly. From these facts the conclusion is drawn that upon these soils the application of lime would yield the largest financial returns.

Further, the results obtained in the examination of all soils described in this paper are of value in indicating a tentative minimum, below which the application of lime is beneficial.

The amount of phosphoric acid dissolved by the method is least from the Serpentine and most from the Chesapeake wheat soils. The amounts removed from each formation per acre foot are as follows:

TABLE XXIII.

| | | Pounds. |
|---|---|---|
| Columbia—truck—Southern Maryland | about | 30 |
| " " Eastern Shore | " | 40 |
| Chesapeake—tobacco | " | 1300 |
| " corn, wheat | " | 925 |
| Columbia— " " | " | 120 |
| Wheat—Eastern Shore | " | 60 |
| Hudson River shales | " | 45 |
| Gneiss | " | 30 |
| Gabbro | " | 24 |
| Helderberg limestone | " | 85 |
| Catskill Sandstone | " | 50 |
| Triassic sandstone | " | 70 |
| Trenton limestone | " | 70 |
| Cambrian sandstone | " | 70 |
| Serpentine | " | 15 |

As all Maryland soils under present conditions are benefitted by phosphates, what are we to learn from these results? It is probable that the order in which these soils are benefitted by phosphates agrees inversely with the amounts removed by the dilute acid; that is, the Serpentine soils are most while the Chesapeake tobacco soils are least benefitted. The results, as showing the relative need for phosphates of the several formations, agree well with the facts and are very encouraging; but the results do not definitely establish a standard amount, above which a soil does not need phosphates.

## CLASSIFICATION OF SOILS.

The classification of soils for agricultural purposes is of great importance; upon the accuracy with which this can be done depends largely the prosperity of the agricultural classes. It is a matter of common observation that soils differ greatly in their adaptability for the production of various crops. The intelligent farmer recognizes this difference and with the means at his command he classifies the soils with which he comes in contact. The basis of this classification is experience, not necessarily the experience and observation of one man or of one generation of men, but it is the agricultural wisdom of generations of farmers. Upon this basis he accepts the conditions as he finds them, and from them he makes his classification—a classification that for general purposes is usually accurate. When the farmers of western Maryland grow fruit upon the Cambrian sandstone soils and refuse to attempt to grow wheat or grass as a profitable crop, though their land is contiguous to the finest wheat and grass lands of the State—the Trenton limestone—and when, on the other hand, they grow wheat and grass on the Trenton limestone and do not at-

tempt to grow fruit, they have classified these soils. When the farmers of southern Maryland grow truck crops upon the light sandy soils, tobacco upon a heavier soil, and wheat upon their heaviest lands, they have classified these soils. It will be found that in the older and larger agricultural sections each class of soils is, generally speaking, devoted to that branch of agriculture to which it is best suited under existing conditions. A broad general classification of the soils has been made.

Why, then, should we seek other methods of classification? Because experience is the most costly kind of knowledge. He who well acquainted with one branch of agriculture provides himself with lands, stock, and implements for the practice of that branch and realizes too late that his land, by nature, is not fitted to his purpose, is handicapped in the race, while without a change of conditions failure is certain.

Again experience, while it enables us to make a very general classification, does not sharply differentiate soils of nearly equal power. When both are well suited to the kind of agriculture to which they are devoted, this is not a matter of much importance, but when they are close to the limit which marks their profitable use a sharp classification becomes essential. Further, this basis—accepting existing conditions but realizing perhaps the necessity of changing them—does not furnish the data from which we can determine the controlling factor or factors of the soil's present fertility. This data can only be obtained by actual experiments upon the land—a long, laborious, and costly process. As agriculture does not furnish quickly and economically the data for classification, science—physical and chemical—has been called to the aid of the farmer and from the data furnished by one or both, classifications have been attempted. These various classifications have not always agreed with the actual results obtained in the field, and indeed it is not too much to say it is the exception rather than the rule for them to do so.

From the data furnished by the physical analysis, ultimate chemical analysis, treatment with strong hydrochloric acid, and with fifth normal hydrochloric acid attempts have been made to estabiish a system of classification whose results shall agree with the relative order of these soils as determined by crop production. So far these efforts have proved unsuccessful, and for the present at least we must be contented with the establishment of certain broad and general facts. These facts, which are of a practical nature, have been discussed in treating of the results of the chemical examinations and will be summarized later.

## COMBINATIONS OF THE SOIL CONSTITUENTS.

As before stated, we know very little about the different compounds in which the various constituents may exist, and we know even less about the effect of these combinations upon the solubility of the essential plant foods. It is not intended to enter into an extended discussion of these questions at the present time, but it will be sufficient to state briefly what has been proved and what has been indicated by the work of numerous investigators.

*Silicon* (*Si*) is usually expressed in statements of soil analysis as silica ($SiO_2$), which in the crystalline form is more commonly found as quartz. It is abundant in soils, particularly in the sandy soils recently formed. Not all the silicon of soils exists as silica; but it also occurs in simple and complicated combinations with the other elements, particularly with sodium, potassium, magnesium, calcium, aluminum, iron, and oxygen, with which it forms compounds known as silicates. The various silicates, or compounds of silica, which may exist in the soil can not as yet be accurately determined nor can the properties of any one class be rigidly defined. In soil analysis we attempt to divide them into two great classes by treating the soil with concentrated (1.115 sp. gr.) hydrochloric acid, but as stated on page 68 the separation is not a sharp one. However, from Snyder's * results the acid insoluble material seems incapable of supporting vegetation, and it appears safe to conclude that the plant food of this material plays no immediate part in fertility.

Regarding the action of the soluble hydrated silicates the experiments of Way, Eichhorn, and others have shown that the base is easily rendered soluble and replaced by treatment with a solution containing an excess of a different base. This is particularly true with regard to the sodium, potassium and calcium, each of which are very easily removed. Just how much of these soluble silicates or zeolites, as they are frequently called, exist in the soil at any time and just how available the potash and lime are to plants have not been determined. Considerable importance has been ascribed to them, both as conservers and suppliers of potash, lime, and ammonia. Beyond the fact that it is a constituent of important compounds, silicon does not seem to play a direct chemical part in fertility.

It is absorbed in small quantities by the growing plant, and it has been stated that its function is to increase the stiffness of straw. More recent investigations have negatived this idea.

*Potassium* (*K*). is usually stated as potash (K20) and is an essential ingredient in fertile soils. It is derived principally from the decomposition of feldspathic rocks and exists chiefly as silicates of greater or less solubility. Varying small amounts exist in combination with organic matter, generally as what are known as humates. Very minute quantities may exist in simple compounds, such as the sulfates, carbonates, phosphates, etc.

Examination of the analyses of rocks, soils, and drainage waters show that in general the compounds containing potash are among the most insoluble. This conclusion is fully borne out by our results, as will be seen from the following table, which shows the percentage of the total of each ingredient which is dissolved by strong hydrochloric acid.

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* Bull. 41, Minn. Agrl. Expt. Sta.

## TABLE XXIV.

*Percentage of the total of each Ingredient Soluble in 1.115 Sp. Gr. Hydrochloric Acid.*

| Conventional Name | Formula. | Columbia, Truck, Southern Maryland. | Truck Soils. Eastern Shore. | Chesapeake, Tobacco. | Chesapeake. Corn and Wheat. | Columbia, Corn and Wheat. | Corn and Wheat soil Eastern Shore. | Hudson River Shale, | Gneiss | Gabbro | Helderberg Limestone. | Catskill Sandstone, | Triassic Sandstone. | Trenton Limestone. | Columbian Sandstone. | Serpentine, Barrens. | Potomac Clays, Barrens. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| Potash.. ......... .... | $K_2O$ | 5.3 | 7.5 | 30.8 | 33.1 | 16.2 | 8.2 | 16.6 | 14.5 | 21.1 | 30.4 | 18.8 | 21.6 | 14.7 | 9.7 | 11.1 | 9.1 |
| Soda.. ....... . . ... | $Na_2O$ | 18.2 | 6.4 | 16.4 | 34.6 | 27.4 | 9.1 | 50.0 | 6.5 | 15.0 | 47.0 | 32.6 | 59.7 | 19.0 | 22.9 | 5.3 | 15.9 |
| Lime ...... ..... .... | $CaO$ | 9.7 | 26.2 | 22.6 | 17.6 | 33.3 | 29.8 | 63.0 | 34.2 | 32.0 | 54.5 | 38.2 | 77.3 | 50.1 | 27.4 | 17.6 | 11.5 |
| Magnesia. ......... | $MgO$ | 65.6 | 10.0 | 78.7 | 71.2 | 92.8 | 77 6 | 71.5 | 98.2 | 39.5 | 65.2 | 43.8 | 85.6 | 100.0 | 43.8 | 27.4 | 10.5 |
| Manganese oxid.. | $MnO$ | 12.5 | 37.5 | 23.1 | 25.0 | 16.7 | 15.4 | 14.3 | 20.0 | 22.2 | 60.0 | 23.8 | 50.0 | 61.5 | 27.3 | 11.1 | 22.2 |
| Ferric oxid......... | $Fe_2O_3$ | 73.5 | 77.3 | 92.2 | 56.7 | 73.0 | 73.4 | 72.9 | 96.6 | 100.0 | 85.6 | 64.3 | 99.1 | 70.5 | 69.2 | 79.2 | 72.7 |
| Alumina. ...... | $Al_2O_3$ | 100.0 | 26.3 | 57.6 | 71.6 | 39.0 | 55.4 | 70.0 | 56.9 | 72.6 | 55.4 | 43.9 | 49.6 | 72.3 | 35.2 | 39.0 | 24.1 |
| Phosphoric acid . | $P_2O_5$ | 34.2 | 32. | 62.0 | 85.0 | 37.5 | 60.7 | 100.0 | 69.4 | 100.0 | 61.7 | 4.0 | 74.5 | 68.0 | 64.2 | 34.2 | 34.0 |

From this table we see that in nine of the formations potassium is relatively the most insoluble base present. The greater relative solubility of potash in the Chesapeake formation is undoubtedly to be ascribed to the presence of the acid soluble hydrous silicate of iron and potassium — glauconite. In but two instances does the solubility of the potash exceed 25 per cent., while that of the other bases frequently exceeds 50 per cent. and in several instances rises to 100 per cent. From a comparison of the bulk and strong hydrochloric acid analyses it seems that the acid insoluble material consists chiefly of silicates of aluminum and potassium or of iron and potassium.

Concerning the relation to potash fertility of those acid soluble compounds that do or may contain potash, there has been considerable difference of opinion; a difference that is undoubtedly largely due to the indefinite use of the term "zeolite" Mineralogically this term is applied to that class of hydrous double silicates in which the ratio of the protoxid base to alumina is 1 to 3. The agricultural chemist has used the term more indefinitely, and applies it to those acid soluble double silicates whose presence is *indicated* by the increased amount of silica which is soluble in sodium or potassium carbonate after treating the soil with acid; and whose presence is further *indicated* by the soil's power to absorb bases chemically.

From the mass of data upon the absorptive power of soils the following conclusions are warranted. The absorbtive power of soils is of two kinds. In so far as it is physical property it is possessed by all solid matter and it is proportional to the surface; that is, the finer the texture of the solid the more it will absorb. It is not accompanied by a change in constitution of the absorbed body. In as far as absorption is a chemical phenomenon it is only possessed in a measurable degree by certain compounds and is always attended with a breaking down of the body absorbed and the solution of an equivalent amount of another base. Should the solution used be a phosphate or a silicate both the acid and base are absorbed, but probably not in combination.

The existence of "zeolites" in the mineralogical use of the term has not been directly proven; but the presence, in greater or less amounts, in cultivatable soils of compounds, which are capable of absorbing bases from their solution and at the same time yielding to the solution the equivalent of the absorbed base, is beyond dispute. Any soluble base may be absorbed and may replace any other soluble base. Direct proof of the occurrence in or absence from soils of so-called zeolites is of considerable scientific interest; agriculturally speaking, it is not a matter of much importance.

In the many experiments on replacement of bases in no case has the absorbtion or replacement been complete. No matter how dilute was the solution employed, a trace of the base has remained in it; and however concentrated was the solution, some of the replaced base has remained with the compound. This latter fact seems to be due to the conditions under which the experiments have been performed; and there are good reasons to believe that when a double silicate containing a replaceable base is treated repeatedly with a solution containing another base, the existing base will finally be entirely replaced.

The phenomena of fixation and replacement are of interest chiefly because those compounds of the soil exhibiting these properties are the ones which are supposed to contain the reserve potash supply of soils; the supply which, through the action of various agencies—among them fixation and replacement—slowly furnishes available potash to plants. Further, to fixation and replacement has been attributed the conservation of lime and ammonia as well as of potash.

Although a great deal of work has been done upon the relation of the potash compounds to fertility, as yet only very general statements can be made. We may sum up agriculturally the present knowledge as follows:

The potash of the soil exists in two great classes of compounds. First, that class which is insoluble in strong hydrochloric acid and upon which the action of natural agencies or the agricultural application of salts of other bases is so slow that they are of no *immediate* value to plants. More or less slowly this class of componnds changes to the second class which is soluble in strong hydrochloric acid and from which, through the action of the waters of the soil, plants obtain their potash. Further, the availability of the potash in these latter componnds may be hastened by the application of salts of the alkalies or alkaline earths, most economically by lime.

*Sodium* (Na) is usually stated as soda ($Na_2O$) and it is closely related in its chemical properties to potash. It is not an essential plant food in the common acceptance of the term and occurs in soils in much smaller quantities than does potassium—a fact which is due to the usually greater solubility of sodium containing minerals, as may be seen from the foregoing table.

Some investigators have claimed for soda the power to replace potash —that is, to perform the same office—in plant economy. Many careful experiments have failed to prove this; and the beneficial effects following applications of soda salts seem to be due to their power to release potash from the acid soluble compounds—a property, shown by Way and others to be possessed by an excess of any soluble base, and which is discussed more thoroughly under "potassinm." The componnds of sodium are undonbtedly of the same general nature as those of potassinm.

*Calcium* (Ca), conventionally stated as lime (CaO), is an essential element of fertile soils. The total amonnt present varies greatly. It may be from less than 1-10 per cent. to 10 per cent. or more. In the Maryland soils examined it ranges from 0.37 per cent. in the sandy soils to about one per cent. in the heavy clay soils. The averages of the various soil formations differ very little, all being close to one-half of one per. cent. Carefully conducted experiments and general farm practice indicate that lime is not always in the condition to do the greatest good. It is generally believed to occur as carbonate, bicarbonate, sulphate, phosphate, silicates, and aluminates. How much exists in any form in any particular soil, we are at present unable to determine; nor can we determine definitely the relative direct or indirect value of its various compounds, except that the more soluble compounds are of greater value. However, the conclusion seem warranted that when present as silicates or aluminates lime is of lit-

tle immediate agricultural value, either as a plant food or as an indirect contributor to fertility. That lime is frequently largely present in these forms and when so present is not of immediate value is indicated by some of the results given in the preceding tables. We have seen that the total lime is one of the least variable constituents of these soil formations; while the amount soluble in strong hydrochloric acid aries greatly, and in several instances the amount dissolved by weak acid is nearly as much as is dissolved by the strong. This is notably true of the Hudson River shales, Trenton limestone, and Helderberg limestone formations. From the latter two there is not enough phosphoric, carbonate, and sulphuric acid dissolved to combine with more than two-thirds of the lime dissolved by the dilute acid, even if we consider—that all these acids are combined with lime, which is not probable. The balance of lime must be present as acid soluble silicates or aluminates.

These considerations, taken with the fact that these soil formations as well as most other Maryland soils are benefitted by liming, strongly indicates that a great part of their lime exists in these above mentioned silicates and aluminates. Considerable portions of the soluble lime is believed to be present as carbonate or bicarbonate. This is more obviously the case in the strong western soils, where the amount of carbonic acid generally varies approximately with the lime, than it is in Maryland soils, where the lime and the carbonic acid are so low.

Some lime is combined with phosphoric acid, but how much is so combined can not be determined with any accuracy. Concerning the action of lime upon the more insoluble phosphates of iron, alumina, etc., very little is known, but there are experiments which indicate that under certain conditions some phosphate of lime may result. Further, practical experience demonstrates that the assimilation of phosphoric acid from limed soils is greater than from unlimed soils; but whether this is due to an increased solubility and availability of the phosphates or to other actions of lime remains to be proven. For economical reasons lime salts are generally used to decompose the potash silicates of the soil spoken of under "potassium."

The problem of the constitution of the lime compounds of the soil is an extremely interesting and important one, to which too much attention can not be devoted, considering the varied nature of the results following the application of lime.* In the old saw, "Lime enriches the father but impoverishes the son," is expressed the fact that injudicious liming depletes the potash stores of the soil. Frequent application of lime may be required because, as indicated by the preceding table and by many other analyses, the compounds of lime are among the most soluble soil constituents from which the lime is rapidly removed by vegetation and drainage.

*Magnesium* (Mg), usually expressed as magnesia (MgO), resembles lime in many of its properties and is frequently found associated with it. It seems to be essential to the healthy development of plants, particularly of the seed or fruit where it accumulates in large quantities. On the con-

* For a more detailed discussion of the principles of liming and for analyses of various Maryland limes, see Bull. 66 of this Station.

trary, its soluble salts in the absence of lime compounds seem to be fatal to vegetation—a fact which probably goes far towards explaining why soils derived from magnesian limestone are not as fertile as those derived from pure limestone, and also why agricultural lime containing large amounts of magnesia is frequently not beneficial and may even be injurious.

In this connection a particularly interesting point is brought out by an examination of the preceding analyses. The samples representing the Serpentine formation are from the Bare Hills, where no crop can be obtained and where vegetation consists of a few stunted bushes and grasses. Naturally a soil derived from Serpentine rock can not be a very fertile one. However, with the exception of phosphoric acid soluble in weak hydrochloric acid, there is apparently as much of the other essential plant foods at the command of vegetation as there is in some very fertile soils, the Gabbro, for example. The poverty of these soils has frequently been attributed to the large amount of magnesia present.

From the analyses we see that the Triassic is the only formation that approaches the Serpentine in its total magnesia, while the amount dissolved by strong hydrochloric acid from the Triassic is twice as great as from the Serpentine. Further, we see that the compounds containing magnesia are the most soluble in strong hydrochloric acid, and in nearly every instance the amount of magnesia dissolved is greater than the amount of lime dissolved. When we consider the solubility of the lime and magnesia compounds in weak hydrochloric acid we see that in every instance, except in the Serpentine soils, the amount of lime dissolved is greater than the amount of magnesia dissolved; in other words, the Serpentine formation is the only one in which the amount of magnesia dissolved by weak hydrochloric acid is greater than the amount of lime so dissolved. If the poverty of these soils is due to the presence of more easily soluble magnesia than easily soluble lime, then from the results it seems evident that lime is needed on these soils in sufficient amount not only to invert the ratio between lime and magnesia, but also for the purpose of rendering available the relatively large stores of potash and phosphoric acid contained in these soils. The results of an interesting experiment upon the effect of lime and other amendments are to be found in Bull. 66 of this Station, where it will be noticed that the total crop produced during five years on the plot dressed with magnesium oxid was nearly as great as that produced on the plots treated with calcium oxid and with calcium carbonate. The total amount of grain produced on the magnesium oxid plot was greater than produced upon any of the lime plots except the one treated with ground oyster shells. These results are interesting as a contribution to the data upon the replacement of bases, and indicate anew that other alkaline salts may perform some of the offices of lime; but they cannot be regarded as reflecting on the proposition laid down in the preceding paragraph. The small supply of available phosphoric acid probably contributes largely and directly to the poverty of these soils.

Concerning the compounds of magnesia, the indications are that in Maryland soils they consist of the more soluble silicates and aluminates. In soils containing large amounts of carbonic acid some magnesia is undoubtedly present as carbonate or bicarbonate.

*Manganese* (Mn) is usually expressed as maganous oxid (MnO). It is believed to occur in soils chiefly as one or more of the oxids, but it is very probable that it occurs partly as silicate. It is usually present in very small quantities and no importance has been attributed to its presence.

*Iron* (Fe) occurs in all soils, from less than one per cent. in sandy soils to 10 per cent. in heavy soils. It is generally expressed as the oxid ($Fe_2O_3$), which helps to give the red color to the soils. The color of the soils, however, is not necessarily an indication of the amount of iron present. Many light colored soils, such as marsh lands, contain more iron than darker colored soils.

About the combination of iron with other elements of the soil very little is definitely known. Generally it is believed to occur as one of the oxids or hydrated oxids, though it may be present as the carbonate or hydrated carbonate, usually in very small amounts. Further, it is believed that some of the iron is combined in the form of difficultly soluble phosphate. As all of these mentioned compounds are soluble in an excess of strong acid, it is evident from the analyses that in many instances all of the iron does not exist in these forms. In the Truck, Chesapeake, Tobacco, Gneiss, Gabbro and Triassic soils about all the iron compounds are soluble in strong acids; but in the other soils quite a large percentage is insoluble, indicating compounds of greater complexity, probably silicates. From the very low solubility in fifth normal acid it is evident that but small amounts are present as the carbonated and as the hydrated oxids. The effect of iron salts upon the availability of phosphoric acid will be discussed later.

Chemico-physiological effects of iron are as yet obscure. The green color of plants has been ascribed to its presence. Here, as in the case of blood, some of its value is probably due to the fact that it yields oxygen readily to any compound needing it. The presence of its soluble salts in any amount is injurious to vegetation. The injury has generally been ascribed to the poisonous effect of the salt. While soluble iron salts, like many other soluble salts, are injurious and in large quantities even fatal to vegetation, it seems possible that some of the injury attributed to them may be due to the power they, as well as soluble aluminum salts, have of removing phosphoric acid from solution and thus starving the plant. The idea has been advanced that as all solutions of iron salts are acid, this acidity plays an important direct part in killing vegetation; but as iron salts do not seem to be any more injurious to vegetation than an equivalent amount of a magnesia salt, this very plausible hypothesis requires, and is worthy of, further investigation before we can accept it as offering the true explanation for the injury produced by soluble iron salts. Further, soluble iron salts may produce injury by yielding ferric hydrate, which has a cementing action upon the soil particles. This action is well illustrated in the formation of conglomerates where the percolating carbonated water carrying hydrated carbonates of iron are evaporated, depositing the iron compounds and binding the mass of material more or less strongly.

The beneficial effects of iron are largely physical, increasing the power of the soil to absorb and retain heat and moisture and in rendering tillage easier in clay lands.

*Aluminum* (Al) does not contribute directly to the growth of plants and is seldom absorbed in any quantity by the roots. It is usually expressed in soil analysis as alumina ($Al_2O_3$). While the presence of alumina in the soil is problematical it is not improbable that the hydrated oxid ($Al_2(OH)_3$) does exist, at least in some soils. Hilgard* gives analyses of southern and western soils which it seems almost certain contain large amounts of this compound, this particular form of which is probably the mineral "gibbsite." Aluminum also exists in compounds known as aluminates in which it acts as an acid forming element. The best known examples of these compounds occur in cements and are readily soluble in acids. Generally, practically all the aluminum exists as silicates and aluminates, which have been discussed under the preceding bases. About the individual amounts and properties of these but little additional can be said.

*Phosphorus* (P) is conventionally expressed as the pentoxid ($P_2O_5$), commonly but erroneously called phosphoric acid. It is an essential constituent of fertile soils, though it is usually present in relatively very small amounts. It may be less than one hundredth of one per cent and very rarely does it exceed one-half of one per cent. It occurs in organic and inorganic compounds. As the result of the decay the organic changes slowly into inorganic forms.

Concerning the compounds of phosphorus existing in the soil a great deal remains to be learned. While the greater portion is believed to exist as a salt of ortho phosphoric acid, it is not impossible that part may exist in lower forms of oxidation. As phosphoric acid is tribasic three compounds with the same base are possible—the compounds having different degrees of solubility, depending upon the amount and kind of base present. Of the normal salts the iron and aluminum compounds are the most insoluble, followed by those of lime, magnesia, soda, and potash. As the compounds of phosphoric acid are among the most insoluble in water of the soil constituents, it is certain that they do not exist in any amount as salts of potash, soda, magnesia, or as mono- or di-calcium phosphates; consequently they are probably present as the normal phosphates of iron, alumina, and lime. A great deal of work has been done both in the laboratory and in the field upon the relative solubility and availability of these various phosphates. As determined by laboratory experiments the solubility of these phosphates in pure water is about as follows:

| | | | Ignited. | Freshly Precipitated. |
|---|---|---|---|---|
| | | | Parts of Water. | |
| One part of tricalcium phosphate, | $Ca_3(PO_4)_2$ | in | 160,000 | 89,000 |
| " " aluminum " | $AlPO_4$ | " | | 136,000 |
| " " ferric " | $FePO_4$ | " | 733,000 | 161,000 |

It is evident that these phosphates, even when hydrated, are very insoluble compounds which become much more insoluble upon ignition. Further, we see that the iron and the aluminum phosphates are from two

*Vide Report of Tenth Census, also Reports of Cal. Expt. Station.

to five times as insoluble as is calcium phosphate. Of course the soil phosphates are never subjected to the action of pure water but to solutions carrying more or less matter, both organic and inorganic, which may increase or diminish the solubility of the phosphates. In general, it may be said that soil solutions may be expected to increase the solubility of all in the same relative order shown in the table. While it is the tendency of phosphoric acid to form difficultly soluble compounds in the soil—it being presumed that it is with the hydrated oxids of iron and aluminum of the hydrous silicates that it finally unites—not all of the phosphoric acid is believed to be so combined, nor is such combination always effected with marked rapidity.

Numerous experiments by Schroeder, Warrington, Ullman and others prove that with the hydrated oxids of iron ($Fe_2(OH)_3$) and of alumina ($A_2l(OH)_3$) and also with precipitated calcium carbonate and with chalk, phosphoric acid unites very rapidly. The reaction usually is complete in less than three days, frequently in an hour. On the other hand, experiments upon the fixing power of soils for phosphoric acid show that only in the case of soils containing large quantities of calcium carbonate is the rapidity or completeness of fixation nearly so great. In fact the phosphoric acid may not all become insoluble for several months—a fact that probably goes far toward explaining the effects of applications of easily soluble phosphates. These numerous experiments, taken with general agricultural experience, afford strong confirmatory evidence not only of the low availibility of the normal phosphate of iron, aluminum, and calcium but also of the almost exclusive existence of soil phosphates as these compounds.

The fixing power of soils for phosphoric acid being due principally to the easily decomposable salts of iron, aluminum, and calcium, the accurate determination of such compounds and the conditions governing their formation are manifestly of great agricultural importance; but as yet our methods are not so perfected that we can approach these problems with confidence.

*Sulphur* (S) is usually expressed as the trioxid ($SO_3$). It is a usual constituent of soils, about the compounds of which but little is known. It is usually present in sufficient quantities to supply all needs of plants; but at present we are unable to measure the effect of the soluble sulphates upon other soil constituents, particularly those that are essential to plant growth.

*Chlorin* (Cl) is also found in small quantities—in combination with sodium it is generally thought. Its action upon certain plants, such as tobacco is injurious. As with sulphur, in the soils of the humid regions chlorin is not usually present in sufficient quantities to enable us to measure its influence upon the solubility of other constituents; but we do know that sulphates and chlorides, particularly gypsum and common salt, do exert through replacement a great influence upon the availability of potash and they have been quite largely used for this purpose.

*Carbon dioxid* ($CO_2$) is always present in soils, partly dissolved in water and parly in combination with bases. That which is combined is

believed to exist principally as carbonate or bicarbonate of lime. Direct proof of this is lacking and it is probable that some is also combined with magnesia, particularly when the amount of carbon dioxid is large.

Considerable importance must be ascribed to the carbonates in nutralizing acidity, in precipitating organic matter, and in rendering potash and phosphoric acid soluble. The amount present in all Maryland soils is small—a fact that is important, as has been stated, in helping to prove the occurrence of lime as silicate or aluminate.

*Nitrogen* (N) is an essential element of fertile soils, and exists both in inorganic and organic combinations. As the importance of this element is sufficient to warrant separate consideration and as its compounds exert no influence on the amounts and probably but little influence upon the solubility of the other soil compound, its compounds are not treated in this paper.

## PRACTICAL INDICATIONS OF THE WORK.

It has been stated that the immediate object of the Station's soil investigations has been the "determination of the controlling factor in soil fertility." Previous work of the Station upon the physical properties of soils and their relation to water has been briefly referred to. This work has shown that in general soils having the same general physical condition are suited to the same class of crops. It has been shown that the finer a soil is the more water it holds. From this physical work it has been possible to classify quite accurately the soils of the State into four or five great groups having different crop values. But from this data alone it has been impossible to correctly designate the order of the several soil formations within these groups.

In the study of the chemical properties of soils it has been shown that the ultimate chemical analysis of a soil or of a soil formation affords absolutely no reliable basis for a classification.

The solubility of the essential plant foods in strong acids is shown to afford a grouping and an arrangement within the groups that is about as valuable as the results based upon the physical properties alone.

The solubility in weak hydrochloric acid affords about as satisfactory a grouping as either of the above methods.

The systematic classification of these soils upon the combined influences of their physical and chemical properties is as yet possible. There are evidently undetermined factors whose influence is great enough to vitiate this classification.

Our knowledge of the combinations of the various soil constituents has been briefly reviewed and the importance of further work on these points is appreciated

It only remains to discuss the treatment of these various soils in the light of the work so far accomplished.

The most economical means of improving land is by careful and thorough tillage; the heavier the soil the more thorough must be the tillage. Too much stress cannot be laid upon the importance of this matter. We have seen in the preceding pages the effect of the mechanical

condition, and by it alone we may determine within certain limits the value of a soil. In tillage we should aim to approach as nearly as practicable that condition or texture indicated by the mechanical analysis. This is more difficult the heavier the soil, hence heavy soils require more tillage than light soils. The tillage that precedes the planting of a crop is of most value, as thorough preparation of the soil enables the plant to obtain its food easily during the time that it is least able to seek it. Tillage for conservation of moisture should generally be as soon after rain as the land will stand cultivating and should be shallow and flat.

Regarding the fertilizers required by our soils there can be but little doubt that the most needed is lime or lime and organic matter, as lime is known to do best with organic matter. It has been the best farming practice in certain sections of the State for the past fifty years or more to apply lime regularly, the value of this practice has been fully confirmed by recent experiments at this Station and elsewhere. In such sections the use of commercial fertilizers is comparatively new. In this connection an examination of strong soils from various sections of the country is interesting.

These soils, which will be found in the table on page 50, have been cultivated without fertilizers for from fifteen to seventy-five years. Their average yield under these conditions is from 13 to 18 bushels of wheat per acre or close to that of our best soils when well fertilized.

The soil from Tennessee is of the Trenton limestone formation and is, as was to be expected, practically identical with our soils of the same formation. This sample represents the virgin soil. These soils of middle Tennessee have been cultivated from fifty to one hundred years without the application of any manure, but are now beginning to deteriorate and the crops are not what they once were—producing about 13 bushels of wheat per acre. This is the history of these same soils in this State.

The soil from Washington State has been cultivated continuously in wheat for fifteen years or more without fertilizer and averages about 18 bushels per acre. The soil differs essentially from our best soils only in the amount of lime it contains.

Of the soils from the famous wheat regions of Minnesota and Michigan some are higher and some lower than our best soils in potash and in phosphoric acid, and all but one is higher in lime. This one is decidedly higher in phosphoric acid.

These examples which might be multiplied indefinitely, when taken in connection with the demonstrated value of lime in increasing crops, lead us to consider lime (particularly when applied with organic matter) the greatest need of all our soils. Acting as it does, physically to improve the structure of the soil; chemically to release potash, to promote fermentation, to overcome acidity, and probably to release phosphoric acid, its value can scarcely be overestimated. While all these soils are undoubtedly improved by the application of lime the improvement is not as marked on some as on others. If we arrange these soils in the order in which they would receive the greatest benefit from an application of lime it would probably be as follows:

1. Potomac clays.
2. Serpentine.
3. Gabbro.
4. Chesapeake.
5. Columbia.
6. Catskill.
7. Gneiss.
8. Cambrian.
9. Triassic.
10. Wheat—Eastern Shore.
11. Trenton limestone.
12. Helderberg limestone.
13. Hudson River shale.
14. Truck—Southern Maryland.
15. Truck—Eastern Shore.

This arrangement of the soils is based not only upon their lime content but also upon their relative content of other essential plant foods.

Phosphoric acid is probably the substance, which, after lime, is indicated as being most needed by these soils. It is the essential mineral element, which is usually present in the smallest amount. While the best soils of our State contain less phosphoric acid than the best soils of the Central and Northwestern States, it is not believed that they contain less than similar soils of the older States of the East.

According to the analyses in their need for phosphoric acid these soils stand in about the following order:

1. Serpentine.
2. Potomac clays.
3. Gabbro.
4. Gneiss.
5. Truck—Southern Maryland.
6. Truck—Eastern Shore.
7. Catskill.
8. Hudson River shales.
9. Cambrian.
10. Triassic.
11. Wheat—Eastern Shore.
12. Helderberg limestone.
13. Trenton limestone.
14. Columbia.
15. Chesapeake, tobacco.
16. Chesapeake, wheat.

In the order of economic importance the next need of our soils is nitrogen. While we have no data upon the actual nitrogen content of these soils, some information upon this point may be gained by the amount of volatile (organic) matter which they contain and which approximately determines their nitrogen supply.

While we are unable to attempt a classification of these soils in the order of their nitrogen needs, other conditions being favorable the greatest benefit will follow its use on those soils containing the least organic matter.

From the results of the chemical analysis it is evident that the addition of potash is the least needed of the several plant foods. In all the soils it is present in great quantities. Its solubility in the two solvents, concentrated and fifth normal hydrochloric acid, is indicative of its presence largely in an available form, in all but the light sandy soils of the State. With proper cultivation and care to keep up the fertility with lime, organic matter, and phosphoric acid, it is almost certain that the addition of potash to the Trenton limestone, Cambrian sandstone, Catskill, Helderberg limestone, Hudson River Shales, and Chesapeake wheat would not be profitable. More or less benefit would probably attend its application to the Gneiss, corn and wheat—Eastern Shore, Gabbro, Serpentine, Potomac clays, Chesapeake—tobacco, and the Columbia formations, particularly with those crops that draw heavily upon the potash supplies. The light truck lands need a supply of potash in connection with other fertilizers. These indications of the analyses agree well with the general farm experience throughout the State. North of the Baltimore and Ohio Railroad from Washington to Baltimore it is the general experience of the farmers that the application of potash is unnecessary. This is particularly true of those farms that have been limed and whose supply of organic matter has been kept up. In Southern Maryland this is not so generally true, where the tobacco and truck lands are greatly benefitted by fertilizers containing potash.

The reader should keep constantly in mind the fact that this work, its indications, and the conclusions drawn from it, are general in character. They may not apply in all particulars to his individual farm or locality because the local conditions may be different. So in seeking to benefit himself from this work, the farmer must take due account of the local conditions; above all he must give due weight to experience. If with all conditions favorable for the action of lime his soil is not benefitted, crops not increased, then his farm does not need lime. If with a sufficient supply of lime and other plant foods the use of potash is profitable, then his land needs potash.

Experience is a dear but sure teacher. The application of these general conclusions, modified by experience to suit particular conditions, may save both time and money.

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# NOTES ON SPRAYING PEACHES AND PLUMS IN 1900.

C. O. TOWNSEND AND H. P. GOULD.*

## FRUIT ROT.

One of the most serious obstacles in the way of growing and marketing peaches, plums, and stone fruits generally, is the disease known as Fruit Rot. This disease was particularly destructive in this state in 1898, attacking both peaches and plums, and causing a loss of not less than one-fourth of the entire crop of these fruits. In 1899 the failure of practically the whole crop of peaches and plums from other causes precluded the possibility of carrying on experiments for the control of the Fruit Rot. The season of 1900 gave promise early in the year of a large crop of all kinds of fruits and the promise was entirely fulfilled so far as the quantity of fruit was concerned, although the quality was not the best in all cases. Fruit Rot, like most fungous diseases, depends largely upon weather conditions, and since it is impossible to forecast the conditions of the weather for the entire season, it is important to begin preventive measures early enough to keep the fungus from becoming established. In accordance with these observations we began our experiments early in the season before growth had started, with the object in view of finding the best means of controlling the Fruit Rot in this State, and incidentally of determining the general effect of fungicides upon the fruit and foliage of peaches and plums. The weather conditions were such that very little Fruit Rot developed during the past season, and in those orchards where our experiments were carried on there was so little rotting of the fruit that the primary object of our work was defeated. However the effect of the fungicide was so marked upon the foliage and was so beneficial upon the fruit that it has been considered advisable to present the results of our experiments to the growers at this time. In passing, a few facts in regard to Fruit Rot and the methods used in combating it may be of interest and value. While the Fruit Rot seems to depend upon weather conditions, the Rot is due primarily to the presence of a fungus (Monilia fructigena.) This fungus depends very largely for its development upon the state of the weather, and since the fungus itself is invisible without the aid of a microscope, we are liable to think of the weather as the real

*The observations made by Mr. Gould in this connection were purely from the horticultural standpoint.

cause of the Rot. If we compare the weather conditions during the summer months of 1898 with those of corresponding months for 1900, we shall see how the weather controls this disease and to what extent the fungus depends upon external conditions. The most important weather conditions are moisture and temperature, for upon these two the development of the fungus depends, providing the fungus spores are present and in contact with a substance from which the fungus is capable of drawing its food supply. The following table gives a comparison between the rain-fall and the temperature respectively for the corresponding summer months of 1898 and 1900. Table 1 showing the average monthly rainfall in inches and the average monthly temperature in degrees Fahrenheit, with departures from the normal during the summer months of 1898 and 1900 for the two principal peach growing sections of the State.

| | RAIN FALL | | | | TEMPERATURE. | | | |
|---|---|---|---|---|---|---|---|---|
| | 1898 | | 1900 | | 1898 | | 1900 | |
| | Normal | Departure from Normal | Normal | Departure from Normal | Normal | Departure from Normal | Normal | Departure from Normal |
| | WESTERN MARYLAND. | | | | | | | |
| May | 4.64 | +1.03 | 2.41 | −1.18 | 62.2 | −0.3 | 61.3 | −0.8 |
| June | 1.96 | −1.76 | 4.13 | +0.68 | 69.8 | +0.6 | 70.4 | +0.6 |
| July | 3.48 | −0.78 | 4.13 | −0.67 | 75.8 | +3.1 | 75.1 | +1.7 |
| Aug | 6.69 | +4.39 | 2.66 | −0.63 | 72.5 | +1.3 | 76.2 | +4.9 |
| Sept | 1.34 | +1.06 | 1.50 | −1.38 | 66.9 | +0.6 | 70.8 | +4.9 |
| Oct | 6.00 | +4.26 | 1.99 | −1.36 | 54.3 | +3.1 | 58.8 | +7.2 |
| | EASTERN MARYLAND. | | | | | | | |
| May | 4.12 | −0.14 | 2.53 | −1.00 | 62.2 | −1.5 | 64.2 | −0.1 |
| June | 2.25 | −0.44 | 4.06 | +1.48 | 72.0 | −0.3 | 72.1 | +0.1 |
| July | 3.73 | −1.24 | 3.03 | −1.16 | 77.8 | +1.4 | 78.8 | +2.5 |
| Aug. | 6.05 | +3.54 | 3.72 | +0.21 | 76.8 | +2.3 | 78.4 | +3.0 |
| Sept. | 2.24 | −0.34 | 5.86 | +2.54 | 71.2 | +1.4 | 72.5 | +3.0 |
| Oct. | 4.19 | +0.71 | 2.02 | −1.09 | 59.3 | +3.0 | 62.0 | +4.7 |

*This table is compiled from the reports of the Weather Bureau for Maryland for the two years under consideration.

It must be remembered that these averages are made up by taking the daily rainfall and the daily temperature respectively, adding them together and dividing by the number of days in the month, hence it is possible for the figures to be somewhat misleading; e. g., if there was an excessive rainfall for several days in the early part of the month and little or no rainfall during latter part of the month, the average for the month might be very nearly normal. However an excessive average rainfall indicates that the atmosphere was extremely moist on one or more days during the month. It is not especially important in this connection to know whether

the rainy days followed each other closely or whether they were scattered throughout the month, although it is well known that several rainy days in succession are much more conducive to the development of Fruit Rot than the same number of rainy days scattered through the month. An important point brought out by this table is seen by comparing the rainfall in August 1898 with that of the same month for 1900. In 1898 the Fruit Rot was very bad in August and the rainfall was 6.69 inches or 4.39 inches above the normal; while in 1900 when there was no rot, the rainfall for August was only 2.66 inches, which was a little more than half an inch below the normal. It is also a note worthy fact that for the two months preceding August 1898 the rainfall was below the normal and very decidedly so during the month of June; whereas in 1900, August was not preceded by an excessively dry period. In this connection it will be remembered by those who have noticed the matter that an exceedingly moist period preceded by a very dry spell is usually accompanied by an outbreak of fungous diseases. In 1900 this condition does not obtain in any case. Hence, so far as the rainfall is concerned, we find just the conditions that favor the development of Fruit Rot, while in 1900 we do not find those conditions prevailing.

In regard to the temperature we do not find any excessive departure from the normal either in 1898 or in 1900. The greatest variation is to be found in 1900 when the temperature was nearly five degrees above the normal, a condition that is in itself favorable to the development of the Rot but which was fortunately accompanied by a rainfall that was below the normal. Had the rainfall for these two months been as great as in the corresponding months for 1898, undoubtedly the Fruit Rot would have been even more destructive than during that season. However the fact must not be lost sight of that if the fungus could be destroyed or prevented from coming into contact with the fruit, the Rot would not be produced regardless of weather conditions. Where no preventive measures are used the spores come into contact with the surface of the fruit, and under favorable conditions produce slender fungous threads that grow into the fruit and form the brown spots so characteristic of this disease. If the atmosphere is warm and an abundance of moisture is present, the fungus develops very rapidly so that from a set of spores new fungi may develop, complete their growth, and form a new set of spores within twenty-four hours. These spores are capable of germinating at once, and from the fungi thus produced a new set of spores may be formed within the next twenty-four hours. In this way the disease works rapidly, spreading from tree to tree as the spores are carried by the wind. It oftens happens that all the fruit on a tree or on a block of trees may be destroyed in a single day by a rapid spread and development of this fungus. When the fungus has nearly reached its growth it divides into several branches, each of which becomes pinched off at the ends, thus forming several chains of spores, and in this manner a large number of spores may be formed from a single spore in a few hours. If the conditions are not favorable for the germination of the spores, they may retain their vitality even for several years. When the fruit is allowed to remain on the tree after it has been attacked by the fungus, it becomes permeated by the fungous threads, and dries down forming what are known as "mummified

fruits." These mummies soon become covered with an ash grey powder composed of an infinite number of fungous spores. This fungus not only attacks the fruit but it may appear on the blossoms and extend down even into the twigs, as has been known for several years. Hence there is danger of an attack of this fungus from the time the blossoms are open until the fruit is marketed. However the most critical periods for the development of this disease are, 1st, when the blossoms are open, and 2d, when the fruit is ripe or nearly ripe. The Fruit Rot fungus in this state has been most destructive at the ripening season of the fruit. It is not uncommon for the fruit to be destroyed by an attack of this fungus even after it has been packed and is on its way to the market. This condition is brought about by the rapid development of the fungus from spores that had lodged on the fruit previous to the packing.

If this fungus grows downward into the twigs either from the diseased blossoms or from the decaying fruit, as it sometimes does, the twigs are killed for several inches from the tip, producing what was formerly known as the twig blight of the peach and plum. The effect thus produced on the trees is very similar in appearance to the pear blight or fire blight that has been so common and destructive on apple and pear trees for several years. It has been found, however, that while the twig blight of peaches, plums etc., is produced by the Fruit Rot fungus, the pear blight or fire blight of the apple, pear, and similar fruits is produced by bacteria.

*Preventive Measures.*—The first step toward the prevention of the Fruit Rot consists in gathering and burning all the mummified fruits in the fall or early spring. This should be followed by gathering from the trees and from the ground under the trees all fresh fruit that shows any signs of decay, and burning it.

In one of the few orchards in Maryland that produced a fairly good crop of peaches in 1899, the rot was held in check to a very satisfactory degree throughout the entire season by following this plan systematically. The second step in the control of Fruit Rot consists in using some fungicide that will prevent the spores from developing into fungi on the surface of the fruit. Probably the most satisfactory fungicide for this purpose is Bordeaux mixture, at least for the early spraying. Unfortunately this fungicide connot be used for the late sprayings when the fruit is approaching the ripening period, as it is liable to stain the fruit and thus render it unfit for market. For the late sprayings, that is, after the fruit begins to color and ripen, it is better to use some colorless fungicide like ammoniacal carbonate of copper or acetate of copper. The latter is prepared by dissolving six ounces of copper acetate in fifty gallons of water and stirring until it is thoroughly mixed. In preparing the Bordeaux mixture for spraying peaches and plums it should be remembered that the foliage of these trees is comparatively tender *and would be injured by a mixture of the ordinary strength.* It is possible, however to get a mixture that will be effective, and that will not seriously injure the foliage by preparing Bordeaux mixture as follows: Dissolve three pounds of bluestone in water and dilute to twenty-five gallons, slake six pounds of good stone lime and dilute to twenty-five gallons; then pour the two

solutions together and stir vigorously. The number of sprayings will depend upon weather conditions, but as a rule there should be from three to five applications. The first application of Bordeaux mixture should be made before the blossoms open; this should be followed by another spraying soon after the fruit is set, and repeated at intervals of two or three weeks until near the ripening season. Hence the number of sprayings must depend not only upon the weather conditions but also upon the variety of fruit treated, and especially as to whether the fruit ripens early or late. Too much emphasis cannot be placed upon a proper preparation of the fungicide and upon a thorough, systematic application of the same. Even a smaller quantity of bluestone than three pounds to fifty gallons of water may be injurious to the foliage if a large excess of lime is not used, as is shown in Fig. 8, where only two pounds of bluestone with but a slight excess of lime were used in spraying plum foliage, and the same principle applies to peach foliage. In applying the fungicide care should be taken to cover the entire surface of the foliage and branches, and as soon as the fruit has set special pains should be taken to cover it with the fungicide at each spraying. In order to avoid staining the fruit with Bordeaux, Prof. Quaintance of Georgia recommends the use of Copper Acetate for the applications within three or four weeks of the time of the ripening of the fruit. It should also be noted that the application of fungicides aside from their influence in preventing rot and other fungous diseases has a very beneficial effect upon the fruit in giving to it a firmer texture, thus enabling it to go onto the market in a much better condition than it would otherwise do. This point will be more fully brought out in another connection.

## CONCLUSIONS.

1. Fruit Rot may be controlled by spraying the trees with properly prepared fungicides. The number of applications required will depend upon the variety of fruit and upon the weather conditions.

2. As a precaution against the Fruit Rot all mummified fruits should be gathered and destroyed in the winter or early spring; and at picking season, no decayed fruit should be allowed to remain on the trees or on the ground in the orchard, but it should be gathered and burned as soon as noticed.

3. The best fungicide for early sprayings is Bordeaux mixture. This mixture must contain not more than three pounds of bluestone and at least six pounds of lime per barrel. The late spraying should be done with a colorless fungicide.

4. Aside from preventing the Fruit Rot, spraying has a beneficial influence upon the texture of the fruit, especially of peaches.

## EXPERIENCE IN SPRAYING PEACHES.

The experiments outlined below were conducted in the orchard of Mr. Raleigh Sherman, who co-operated to the fullest extent possible in the work. As previously stated, the principal object in view in conducting these experiments was to control the Fruit Rot, but although this disease did not appear to any appreciable extent, another fungous disease known as Black Spot was abundant and therefore very destructive.

FIG. 8.—FOLIAGE INJURED BY BORDEAUX MIXTURE (4-4-50) PRODUCING WHAT IS COMMONLY KNOWN AS THE SHOT-HOLE FUNGUS EFFECT.

Black Spot is produced by a thread fungus somewhat similar in structure to the Monilia that produces the "Fruit Rot." The black spot fungus usually attacks one side of the peach only and prevents the diseased side from growing, thus producing a one-sided fruit. In addition to this, the diseased side assumes a black or brown color and eventually cracks, thus rendering the fruit practically worthless either for market or for home use. It is apparent that this fungus is not affected by the same weather conditions that prevent the development of Monilia, since the Fruit Rot failed to develop where the Black Spot flourished. The same treatment that will prevent the Fruit Rot from developing will also control the Black Spot. Furthermore the spraying that will prevent the Black Spot will exert a beneficicl influence upon the texture of the fruit, as will be seen in the following experiments:

The varieties of peaches which entered into the experiments were Chair's Choice, Salway, Smock and Heath Cling. The first spraying was done March 23rd. A portion of the trees were sprayed with normal Bordeaux; the remainder with Bordeaux containing three pounds of bluestone to a barrel of water. (The potassium ferro-cyanide test for the lime was used in each case, a large excess of lime being added). The second application was delayed until May 26th. The trees were, of course, in full foliage at this time and growing vigorously. A portion of the trees treated March 23rd were omitted at this time to study the effect of a single, early application; also another lot was given the first application on this date. All of the spraying at the second application was with the weaker Bordeaux (3 lbs bluestone) to avoid injury to the foliage. However, the leaves were somewhat damaged by this strength though not seriously. The third and last application was made June 29th. On account of the injury worked by the spray May 26th, a still weaker Bordeaux was made, using two pounds of bluestone to a barrel of water. But even this strength produced a slight shot-hole-fungus effect. One lot of trees received their first treatment on this date.

The following is a concise summary of the spraying: One lot sprayed very early, March 23rd; one lot sprayed March 23rd, May 26th and June 29th; one lot sprayed May 26th and June 29th.

Results: As previously stated, no comparisons could be made as to the effect of the treatment on the Fruit Rot, since practically none of it developed in the orchard. However, the effects of the spraying were very marked in the texture, firmness, and size of the fruit, and the absence of the Black Spot. In all the varieties, the trees sprayed only once, March 23rd, were no better than the unsprayed trees, but the fruit on the trees sprayed three times and those sprayed twice (May 26th and June 29th) was very decidedly better than on the untreated trees. There was no appreciable difference between these two lots—whether sprayed twice or three times. These results do not indicate any advantage in the early spraying before growth starts.

Fig. 9 compares the fruit taken from a sprayed and an unsprayed tree, the fruit on the left being from the former; that on the right from the latter. The fruit in the illustration was as nearly representative as it was possible to select. The sprayed lot was firm, solid, and almost entirely free from Black Spot; the unsprayed had a leathery texture, and much

(SPRAYED.) (UNSPRAYED.)

FIG 9.—REPRESENTATIVE FRUIT FROM A SPRAYED AND UNSPRAYED TREE. THE FORMER IS ON THE LEFT; THE LATTER ON THE RIGHT.

of the fruit was worthless on account of the Black Spot. The importance of continuing the spraying well up to the time of ripening is emphasized in the fact that the earliest variety in the test, Chair's Choice, showed the most decided improvement of any of the varieties. The longer time that elapsed between the last spraying and the maturity of the later varieties gave more opportunity for the development of fungous diseases. But as before stated, the difference in the later kinds was decidedly marked. The fruit in the illustration is one of the later varieties.

The following letter from Mr. Sherman who has observed the results very carefully, is significant:

CHAS. O. TOWNSEND, ESQ.., NOVEMBER 3, 1900.
*State Pathologist,*
*College Park, Md.*

MY DEAR SIR:—In reply to your letter of some days ago requesting my opinion in the matter of the experimental work in spraying fruit trees to prevent Black Spot and other fungous diseases in my orchard this season, I am pleased to inform you that the result was most apparent, gratifying and profitable. In the most positive way permit me to assure you of your success, and to express my belief in the practicable, beneficial and profitable results of spraying.

Crossing my orchard as you did from east to west and spraying Chair's Choice, Salway, Smock and Heath Cling, demonstrated the greatest value of your work alike on different varieties. The treatment produced perfect fruit; there was no black spot or other fungous growth,no mottled spots or withered sides; the texture was fine,and the fruit was plump, well developed, and highly colored, with a staying power on and off the tree that seemed remarkable. My sales and shipping book indicate that the sprayed trees ripened from ten days to two weeks later in the varieties indicated, and that the sales in every instance were at a higher rate, due, I believe, to the superior quality of the fruit, which was so apparent that it was the common talk of the pickers. One even ventured his weekly earnings that he could designate, blindfolded, the sprayed from the unsprayed fruit on the trees in the same varieties, and no one dared cover his offer.

I trust that it will be possible for you to continue your good work next season, and for the benefit of all fruit growers that you will give wide publication of your method.

At this early day it gives me pleasure to extend to you a most cordial invitation;and to assure you that you and all the state officials will always be very welcome in my orchards.

Sincerely yours,
(Signed) RALEIGH SHERMAN.

In addition to this letter, little need be said in regard to spraying peaches either from the standpoint of preventing disease or with a view of improving the texture of the fruit. It is important, however, to consider the cost of spraying in order to determine whether or not it will pay to spray. During the past season bluestone could be obtained at from five and one half to seven cents per pound, and using three pounds of bluestone to fifty gallons of water would make the bluestone cost, at the highest rate, twenty one cents per barrel. Stone lime may be obtained in Western Maryland at a price so low that the cost need not be considered,

and in sections where it is necessaay to purchase it in bulk it may be had for one-half cent per pound. Hence six pounds or enough for one barrel of Bordeaux mixture would cost three cents, thus placing the cost of material for one barrel of Bordeaux mixture at twenty-four cents, or a little less than a half cent a gallon. On an average one gallon will thoroughly spray one tree,hence the material for spraying one tree five times would cost less than three cents for the season. To this,of course,should be added the cost of labor. Three men can work to the best advantage; one to drive and do the pumping, and the other two to handle the nozzles using two lines of hose. The rapidity of the spraying will depend upon the individuals and upon the convenience of obtaining the water for the Bordeaux mixture, etc, but the expense for labor should not exceed three cents per tree for the five sprayings. Hence it is safe to say that an orchard may be sprayed thoroughly five times at an outlay of not more than six cents per tree.

## CONCLUSIONS.

1. Bordeaux mixture containing 3 pounds of bluestone to a barrel of water applied the last of May is likely to injure peach foliage somewhat, but in our experience the injury is not enough to do any serious harm. The same is also true of Bordeaux containing two pounds of bluestone, applied the last of June.

2. Black Spot was almost entirely prevented and the texture and size of the fruit decidedly improved by two and three applications.

3. As the results from the trees sprayed May 26th and June 28 were as marked as from the trees receiving an application March 23rd in addition to the two later sprayings, it follows that the earliest application is without material advantage under the conditions existing at this time.

4. The spraying should be continued well up to the time of ripening of the fruit.

## EXPERIENCE IN SPRAYING PLUMS.

Our work on plums was carried on for the most part in the orchard of Mrs. S. J. Cady, Keep Tryst, Washington County, Md Several parallel experiments were carried on in the orchard of Dr. S. S. Buckley, at College Park, Md. Mrs. Cady's orchard is eight or nine years old, in fairly good condition, and is composed of a large number of Japan and domestica varieties—in all, several hundred trees. Previous to this year the orchard had borne only one full crop of fruit. Many of the trees bore each year a small quantity of fruit, but this was nearly always destroyed by the rot.

The question of the unproductiveness of this orchard was presented to us and after an examination of the conditions, the most probable cause seemed to be the working of the Fruit Rot fungus early in the season, perhaps even during the blossoming period, as the trees bloomed full every year but the fruit failed to set. Accordingly our experiments were planned to determine, if possible, if this conjecture was correct. However, a full crop of fruit set on nearly the whole orchard, thereby defeating the particular object of the experiment. Yet the effort was not entirely barren of results, though so far as the controlling of the disease is

concerned, but little was accomplished. The fact that there was practically no rot in or near this orchard during the past season would tend to bear out, negatively at least, our conjecture in regard to the cause of the failure of the fruit to set in previous years. The following is an outline of the experiments, with the lessons which they teach:

On April 18th before growth had commenced, the first spraying was done. At this time three rows—A, B & C, were sprayed with Bordeaux mixture containing six pounds of bluestone to a barrel of water and more than enough lime to neutralize the bluestone. Light showers occurred frequently while the spraying was being done but examinations of the trees later made it evident that the material had not been seriously washed off. The second application was made May 11th. On this date the foliage was well out, and to avoid danger of injury to the leaves, the strength of the Bordeaux was reduced to four pounds of bluestone to a barrel of water. How much this caution availed will be explained later. At the second application four rows were sprayed, but this time B, C, D, and E; that is, one row, A, sprayed April 18th, was omitted and row E received its first treatment; rows B, C and D received their second application. The object of this was to throw whatever light was possible on the effect of spraying at different times. June 22nd was the date of making the third application. Rows A and B were not sprayed at this time; rows C and D were given a third spraying, E a second and F received its first treatment.

It had been our plan to use Bordeaux on these trees throughout the season but injury to the foliage of the Japan plums caused by the weak Bordeaux (4 lbs., Bluestone to a barrel of water) applied May 11th was so great that this plan was dropped and ammoniacal solution of copper carbonate used in its stead. However, one row (G) was sprayed with a very weak Bordeaux mixture containing two pounds of bluestone to a barrel of water. This completed the spraying for the season, making one row that received a single early treatment, one row that received the first two applications each being Bordeaux mixture; two rows that received three applications, the last being ammoniacal solution of copper carbonate; one row had the two later applications, and two rows had only the last spraying, one being sprayed with ammoniacal solution of copper carbonate, the other with very weak Bordeaux.

The orchard was visited frequently and a summary of the notes that were taken from time to time is given below.

### EFFECT ON DOMESTICA VARIETIES.

The domestica varieties seemed to be entirely uninfluenced by any of the applications so far as the Fruit Rot was concerned, there being as much rot on the sprayed trees as on the unsprayed. The Japan kinds appeared to be rather more amenable to the treatment, though the results were not so satisfactory as it was hoped that they would be. Row A, which received only the early application and rows F and G which were given only the latest spraying showed no influence of the fungicides. The three other rows showed some improvement in the condition of the fruit though it was not very marked.

## EFFECT ON FOLIAGE.

The effect on the foliage was much more emphatic than upon the fruit, though this effect was anything but pleasing. The domestica varieties were in no wise injured but the extreme tenderness of the Japan sorts was very emphatically demonstrated. As above stated, the Bordeaux containing four pounds bluestone to a barrel of water applied May 11th, was so severe that its use at this strength was precluded. Many of the leaves dropped within a few weeks after the spraying and nearly all that remained on the trees were full of small holes where the tissues had been injured. These subsequently died and broke away from the healthy tissue. (Fig. 8.) A good many of these leaves fell prematurely, but the trees put out many new leaves so that on examination Sept. 19th the loss of foliage was not conspicuous, though the "shot-hole-fungus effect" was still apparent on the older foliage.

July 14th it was noted that there was no apparent injury from the Bordeaux containing two pounds of bluestone to a barrel of water, but on Sept. 19th practically all the leaves had fallen while the unsprayed trees were in full leaf. It may be well to state that the "potassium-ferrocyanide test" was used for the lime, in the Bordeaux, a large excess of lime being added. The ammoniacal solution applied June 22d produced considerable "shot-hole-fungus effect," but not enough to cause any serious dropping of the leaves. This injury was apparent on July 14th but on this date it manifested itself merely in the spotting of the leaves, while later this injured tissue dropped out of the leaves, leaving the holes referred to.

A summary of the condition of the foliage Sept. 19th may be briefly stated as follows:

From the ammoniacal solution the effects were slight as to the dropping of the foliage but there were many holes in the leaves; from the Bordeaux with four pounds of blue stone, many leaves showed the holes or "shot-hole-fungus effect"; a considerable portion dropped after the application but it was made early enough so that many new leaves put forth making the lack of foliage unnoticeable at this date. From the Bordeaux with two pounds bluestone, the trees were nearly defoliated. Perhaps it should be stated that, without doubt, the foliage in mid-season is more susceptible to injury from sprays than it is early in the spring.

The plum trees owned by Dr. Buckley are young and in a healthy condition. The few crops that the trees have borne in previous years rotted for the most part before they ripened and it was fair to suppose that under the same conditions the rotting would be repeated. As already stated it was impossible to foretell what the conditions would be, hence we began spraying soon after the leaves had developed. The first application was made on May 8th and this was followed by a second spraying on May 23rd. The varieties sprayed were Abundance and Ogon. Several trees of each variety were sprayed and a number of each were left with no treatment. Two strengths of Bordeaux mixture were used, viz: Four pounds of bluestone and four pounds of lime to fifty gallons of water and two pounds of bluestone and two pounds of lime to fifty gallons of water. Both these strengths of Bordeaux mixture were very injurious to the foliage, a large part of which dropped off, the remainder

being badly injured by the fungicide. The Bordeaux made up on the 2-2-50 formula produced just as much injury as did the stronger mixture. In all probability a large excess of lime would have prevented the injury with the plums as it will in the case of peaches. The sprayed trees soon put out new foliage but it did not reach the same size and it remained somewhat paler in color than the original foliage.

The effect of the injury to the foliage was as marked in the development of the fruit as it was in the development of the new foliage. Nearly all the blossoms on both the sprayed and the unsprayed trees set fruit so that all the trees were loaded, but on the sprayed trees where the foliage was severely injured the fruit was very much smaller than on the unsprayed trees. It was also noticeable that the fruit on the trees with the injured foliage was much inferior in quality to the fruit on the unsprayed trees. This serves to show how the size and quality of the fruit depend upon a normal development of the foliage. If the foliage is injured in any way whatever, whether it be by artificial means as in the case just described or by some natural cause, as in the case of a fungous disease, the result will be the same so far as the size and quality of the fruit is concerned. No fungous disease of any importance appeared either on the fruit or on the foliage of any of the trees whether sprayed or unsprayed. It is true that a few cases of Fruit Rot appeared late in the season, but they were very few in number and just as many appeared on the sprayed as on the unsprayed trees; hence no conclusions could be drawn in regard to the effect of the spray upon either the Fruit Rot or other fungous diseases.

## CONCLUSIONS.

From the season's experience,

1. Bordeaux mixture seems to be more effective in preventing Fruit Rot of Japan plums than of the domestica varieties.

2. To be effective in preventing this disease, the spraying should be begun early in the season, but the value of an application before the foliage puts forth was not demonstrated in the fore-going experiments. The application should be continued near to the period of ripening.

3. Bordeaux mixture containing four pounds of bluestone to a barrel of water applied in May will seriously injure the foliage of Japan plums.

4. Bordeaux mixture containing two pounds of bluestone to a barrel of water applied as above,the last of June will seriously injure the foliage. This strength, however, might be safe earlier in the season.

FIG. 16—Three-year-old orchard growing on site of first orchard near Keedysville. See page 181 (Photo taken Dec. 2, 1900.)

# THE MARYLAND AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 72. March, 1901.


# OBSERVATIONS ON PEACH GROWING IN MARYLAND.

By H. P. Gould.

## INTRODUCTORY STATEMENTS.

The development of the peach growing industry in Maryland has been, and still is, a leading factor in the agricultural economics of certain sections of the state. While the growth of the industry has taken place principally in a small number of counties, the fruit is grown to a greater or less extent in every county in the state.

During the past two seasons the writer has spent much time in the peach growing centers of the state and has observed conditions and methods as fully as time permitted. Much yet remains to be done to complete a systematic study of the industry but it seems expedient to make a preliminary report at this time.

In the following pages, the object is to discuss fundamental principles rather than to treat the minute detail, although the trend of the subject matter is largely governed by the impressions that have come to the writer in studying the conditions under observation. It is hoped that some of the suggestions made may bear fruit.

## HISTORICAL NOTES.

Peach growing has long been one of the leading agricultural industries of Maryland. The first large orchard seems to have been planted by Thomas Robinson about the year 1800. This orchard was located in Anne Arundel county about 20 miles south of Baltimore. It consisted of 18,000 to 20,000 trees; these were all natural seedlings. It was evidently in the days of peach brandy, for the entire product of this orchard was used for this purpose.

Some ten years later, or about 1810, a number of small orchards were planted within a radius of five or six miles of Baltimore, the fruit of which was disposed of in the town. The names of Richard Cromwell, Abner Linthicum and Ellis Thomas are associated with these orchards. The one owned by Mr. Thomas was situated where Cedar Hill Cemetery now is. In 1850, or about this date, Mr. Wilson planted an orchard on Magothy River. This orchard was well cared for and was very satisfactory.


NOTE:—I wish to make grateful acknowledgment of the assistance that has been given me in the preparation of this bulletin. Such acknowledgement is due those who have furnished me with historical facts and to the various transportation companies that have given me data required for estimating the peach crop. The assistance received from other sources is no less appreciated.

It produced 21 crops in 24 years. By this time the industry had reached a considerable magnitude in this county. Some of the varieties planted in these orchards were Reybold's Early Cluster, Belle de Vetry, Orange Cling, Lemon Cling, Red Mandelin, Malecatone, Teton de Venus, George IV, Early Newington, Late Newington, Early Admiral, Late Admiral.

Just when the first commercial orchard was planted on the Eastern Shore is not clear. It is said that Maj. Phillip Reybold planted an orchard of 6,000 trees in Kent county about 1830, near the head of Chesapeake Bay, on what is known as Plum Point farm. It is, however, a well known fact that Major Reybold became an extensive planter a few years later. About 1830 a Mr. Cassidy planted 50,000 peach trees in Cecil county along the Sassafras river. The land on which these trees were planted was worn out but by judicious management the orchard proved very satisfactory. Mr. Cassidy was a grain merchant in Philadelphia and owned numerous teams in the city as well as a number of sailing vessels in connection with his grain business. As he thus had abundant means of transportation he collected, so it is said, all sorts of debris from old buildings in the city and shipped it to his farm. This was applied to his orchard in liberal quantities, and, no doubt, greatly improved the physical condition of the soil. The trees were systematically pruned and well cared for and the orchard seldom missed a crop of fruit. After the owner's death in the early fifties, the orchard was badly neglected. I am told that for several years after this occurred, there still remained large quantities of the debris, which had been shipped from Philadelphia, that had never been applied to the orchard. But the orchard bore several profitable crops of fruit after this in spite of the neglect. The good care given it in the earlier years still manifested itself. Mr. Richard Semans of Cecilton and some others also planted smaller orchards about this time. The fruit from these early orchards was transported to market by sailboats or in large wagons; railroads and steamboat lines had not then been established.

"In Kent county, about 1842, Major Phillip Reybold, of Delaware City purchased land in the third district in Kent county and planted it largely to peaches. This orchard proved a success. The greatest impetus to peach planting was made from 1856 to 1865. In 1856 Col. Edward Wilkins, of Kent county, on the Chester river, commenced to plant largely and in a few years he had 1500 acres in cultivation, and in several instances he would realize a handsome fortune out of his orchards in a single season. From 1856 to 1865, peaches were planted all along the water courses in the first district of Cecil county, in all of Kent county, and in parts of Queen Anne county, until there was a continuous forest of peach trees all along these water courses and extending from one to two miles back from the water; but in the interior counties on the Eastern Shore, peach planting did not commence largely until about 1867 to 1875. At this time the Delaware railroad was finished through that State and branch railroads were talked of in every county on the Eastern Shore. Trees were then planted all along the lines of these railroads." *

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* J. T. Shallcross in First Annual Report of the Maryland State Horticultural Society.

The canning of peaches began about the middle of the century. A son of Major Reybold was one of the first, if not the first, to develop this phase of the industry. His establishment was on what is known as "Buck Neck" farm. A Mr. Fahnestock also became interestsd in canning peaches about the same time. He is said to have been an extensive operator.

It will thus be seen that peach growing in Maryland, from a commercial standpoint, had its origin in Anne Arundel county, though the Eastern Shore is the section that gave to the state its prestige among peach growing areas.

Peach growing in Washington county is a comparatively recent development. The first commercial orchard in this section of the state was planted in 1875 at Edgemont. Mr. John A Nicodemus was the pioneer. There were then small family orchards but none of commercial importance. It was the behavior of these small orchards that first led Mr. Nicodemus to venture on a more extensive scale. Realizing the opportunity before him, he soon began extensive planting. His early venture comprised about 60 acres. The most of the fruit was shipped to Chip Chase Bros., a commission house in Baltimore. The package used in these early days was a bushel crate. The crates were sent to the shipper by the commission house that received the fruit.

Much interest centers about this first orchard planted by Mr. Nicodemus, though his undertaking was looked upon lightly in those days by most people. He gave the orchard good care and it was successful. It was several years before any other commercial attempts were made. In fact, it was not until Mr. Nicodemus' orchard commenced bearing that people began to realize what opportunities they possessed. In this early orchard many received their first instructions in peach growing. It was the "cradle" of the industry in Western Maryland. It is fortunate that the "father of peach growing" in this section of the state appreciated the importance of careful attention to his orchards.

The first orchard planted in the vicinity of Keedysville, which is one of the largest shipping points in Western Maryland, was put out in 1880 by Mr. W. D. Hughes. Having had some experience with peaches near Smithsburg, Mr Hughes became possessed of a desire to extend his operations and after prospecting for a suitable place for peaches finally decided upon a mountain location about two miles from Keedysville. Mr. Hughes still cultivates this original tract and the three year old orchard shown in Fig. 1 is growing on the site of the original orchard planted in in 1880. The first planting consisted of about 3000 trees. The next two or three years saw other plantings of nearly the same number. The prices obtained in these early years seem phenomenal when compared with present day prices. Bushel crates sold for as high as $7.00 per crate and fruit packed in the Jenkins carrier holding about one-thirds of a bushel brought $5.50. These prices, however, indicated that in those days peaches were looked upon only as a luxury for the rich.

It ought to be mentioned in passing, that in 1884 Mr. Hughes shipped peaches to Liverpool and to California. This, however, was intended as a test for the Jenkins carrier, rather than for a commercial enterprise. Two

shipments across the ocean were made. The first was the Smock variety and was fairly successful. The second attempt was all that could be desired. Bilyeu's was the variety; the fruit was picked before it was as soft as the Smock in the first shipment. So far as I know this is the first attempt in this country to send peaches across the ocean. Mr. Hughes gradually extended his operations to other sections of the county.

Closely following the first plantings in this section, came the early efforts of Messrs. A. C. and E. A. Pry. In fact, Mr. Hughes and Mr. A. C. Pry prospected together before any attempt was made to grow peaches here. Messrs Pry have been gradually increasing their peach interests from the first, until now they are among the most extensive growers in the state.

Many of the Western Maryland orchards are on the Blue Ridge Mountains; the first orchards in this section were so located; but gradually extensive plantings have been made on the lower levels. Mr. Luther Barkdoll of Ringgold is said to have been the first to plant away from the mountains. Some of the most profitable orchards in the state are growing on land, the commercial value of which, within the memory of men now living, was only a penny an acre.

The foregoing is a brief outline of the beginning of peach growing in Western Waryland. Its extension and development has been merely a natural consequence of the situation. The earlier efforts were successfull and others, following the lead of the pioneers, have made the industry what it is today. In a general way, this has been the line of development in all the peach growing sections of the state. The pioneer or venturer came first; he succeeded and others naturally followed.

## PRESENT STATUS OF THE INDUSTRY.

It is impossible to form an accurate estimate of the extent of peach growing in this state but from data that has been collected, some conception can be formed of its present magnitude. The bulk of the peach crop is produced in five counties—three Eastern Shore counties and two Western Shore. As nearly as can be determined the following figures represent the extent of the industry in the various counties.

| | | |
|---|---|---|
| Washington county | 1,000,000 | trees |
| Kent county | 450,000 | " |
| Caroline county | 450,000 | " |
| Anne Arundel county | 300,000 | " |
| Queen Anne county | 300,000 | " |
| All other counties | 500,000 | " |
| Total | 3,000,000 | " |

During the past two or three years the majority of the orchards in Washington county and practically all of them in Kent have received an official inspection and a careful record kept of the number of trees in the different orchards. A considerable portion of the orchards in Caroline county have also been inspected. The estimates relating to the other counties mentioned have been supplied by fruit growers living in these counties who are familiar with the conditions which exist. There are many

orchards, more or less isolated, in all parts of the state and the aggregate number of trees in such orchards is large. Probably, however, the estimate made for "all other counties" is excessive. I would place the total number of trees at from 2,500,000 to 3,000,000. It may be assumed that 2,000,000 of these are in bearing.

If the size of the orchards in Kent county is representative of all the Eastern Shore orchards, it appears that in this section the orchards are considerably larger than the most of the orchards in Washington county. Of the 200 orchards inspected in Kent in 1899 the average size is about 2000 trees. The largest one contains about 14,000 trees but there are only a few consisting of more than 5,000. The records at hand show 16 orchards between these two limits. In Washington county perhaps the average of all the orchards is not very different from the average in Kent but not including those of 10,000 trees or more, the average in Washington county is from 500 to 800 trees less than in Kent. In Western Maryland there are about 12 growers who manage orchards of 10,000 trees or more. A number of these growers cultivate from 40,000 to 60,000 trees.

## THE CROP OF 1900.

The abundance of this crop will long be remembered in the history of peach growing. This condition prevailed not only in Maryland but in all the peach growing sections of the country. No accurate estimate of the yield can be readily made. The most of the transportation companies that have handled the fruit have kindly given me the records of their shipments so that with this aid, some idea can be formed of the product that was marketed, though the following estimate does not include the thousands of bushels that were taken directly from the orchards to local canning houses. As nearly as can be determined from the data at hand, the number of packages marketed through the channels of the different transportation companies reached not less than 2,000,000, probably more. The actual number reported, after making certain estimates where the data was given in pounds, was 1,847,990. This includes crates, carriers, and baskets. Although several companies made no report, the above estimates are based on data furnished by the principal channels through which the fruit found its way to the markets and it may be considered as indicative of the amount of fruit that was actually shipped to the open markets, even though it appears rather small, considering the number of bearing trees. The cash value of this product to the grower may be an interesting point for speculation.

## SUGGESTIONS FOR STARTING AN ORCHARD.

*Choosing the Location*:—There is probably no section of the state where peach trees cannot be grown, yet there are many places where they are not likely to become a commercial success. In some sections the cold of winter is a factor in this consideration, but late spring frosts which occur while the trees are in bloom cause many failures of the crop. There are many orchards in the state which have missed three or four successive crops on account of late frosts, or severe freezes after the buds have begun to swell. The "frost factor" should be carefully considered in choosing the location.

While a "peach soil" is generally cons dered to be a light, porous or sandy soil, this factor admits of a wide range of variation; we find peach trees doing well on nearly all kinds of soil, provided it is well drained and the physical condition good. Attention, however, should be called to the fact that there is a difference in varieties with regard to their adaptability to different soils. Not all varieties will do equally well in the same soil.

*Preparation of the Soil:*—Everyone realizes the folly of sowing wheat or planting corn without first putting the land in first-class condition. But these are only annual crops, and if the ground has not been well prepared for them the mistake can be corrected the next season, when the succeeding crop is put in. How much greater then the folly of putting in a crop which is to occupy the land for ten or twenty years without first giving the soil the best possible preparation!

A common practice among Maryland growers, and one to be commended, is to plant the orchard on land that was in some cultivated crop the previous season.

The gist of the whole matter is this: The soil cannot be to well prepared before planting the trees. It is difficult to correct faulty preparation after the trees have been set.

*Selection of Varieties:*—Fruit growers are becoming more and more impressed with the fact that a variety is largely the expression of the conditions under which it is growing; that because a variety is a success in one place, is not a sufficient reason why it should be satisfactory in another place where the environment is different. Some varieties are more cosmopolitan than others and will do well under a great variety of conditions; other varieties are very susceptible to the conditions under which they grow. In speaking of the varieties in their orchards, many Maryland growers have said to the writer that were they planting another orchard, they would not plant this kind or that, because they have not proven successful. These unsatisfactory kinds, however may be desirable in other places where the environments are better suited to them. Trees are as sensitive to their surroundings as men are!

In choosing varieties, the safest guide is to study the behavior of the desired kinds, growing under conditions similar to those where the trees are to be set out, and to be governed thereby in making the selection.

*Selection of Stock:*—False economy is frequently practiced by purchasing second quality trees because they can be secured at a little less cost than first-class trees can, but a tree that is poor when it is set out is apt to remain poor all its life. If only a certain sum can be expended for trees, it is better in the end to buy a smaller number of good trees than to get a larger number of second rate stock. Mere *bigness*, however, does not determine the quality. A well grown tree of medium size, healthy, thrifty, free from all blemish, possessing good roots, and true to its type is of first class grade; while a *large* tree may also be first class and a *small* tree need not necessarily be unhealthy, the tree of *medium* size is usually best. A weak, stunted, poorly grown tree should not be planted.

FIG. 11.—Peach trees, unpruned and pruned. The latter is ready for planting.

*Preparation of Trees for Planting:*—As a rule the roots are more or less injured and broken when the trees are dug from the nursery. All broken and injured portions ought to be cut off. In trimming the top it is a common practice, unless the tree is very large, to cut off all the branches, leaving nothing but a straight "whip". The top of this is cut off at a distance above the ground about equal to the desired length of the trunk of the tree.

If, however, the tree is large and the top consists of relatively large branches, the probabilities are that the buds along the trunk are small and weak and would not readily start into growth, many being too weak, perhaps, to start at all. Thus the top would be irregular if these buds were relied on to form it. In such cases the tree may be pruned as suggested in Fig. 11, leaving short spurs bearing each a single, well formed bud. Subsequently the ones best placed for forming the top can be selected and the others removed.

## EARLY CARE OF THE ORCHARD.

Perhaps there is no phase of orchard management in which the invidualty of the grower will manifest itself more prominently than in the detail of the care which he gives his orchard. And whilst the detail of one grower may be quite different from that of some other, both may be equally successful. Methods vary but the underlying principles are the same.

FIG. 12—Splitting caused by top being improperly formed.

*Starting the Top:*—Whether the trees are headed high or low is not a fundamental principle but an individual preference. Convenience in picking, pruning, etc., however, favors a low head. The most essential feature is to form the top of branches which start from various points along the trunk. Fig. 12 shows a tree in which the three main branches all started from the same level thus concentrating to one centre the weight of the top; increased by a heavy crop of fruit, the strain was greater than the tree could bear. If these branches had been well distributed, it is safe to assume that the tree would not have suffered, as it was not more heavily laden with fruit than many others close by it.

*Inter-cropping:*—The custom of growing some crop between the trees until they have reached the bearing age is not necessarily a pernicious one, but as often practiced it becomes so. The grower should keep in mind that he is practicing a system of double cropping—growing two crops on the land at the same time. The most important of these crops is the p ach orchard. But there are many who want just as much corn (if that is the inter-planted crop) from a ten acre p ach orchard as they would expect from it if the peach trees were not ther . The grower ought

to be satisfied if the returns from the inter-planted crop pay for taking care of the orchard.

A hoed crop of some kind should be selected if inter-planting is followed. The cultivation usually given such a crop will favor a satisfactory growth and development of the peach trees. The growing of grain in a young orchard should be condemned. It prohibits all tillage and the trees are certain to suffer from lack of moisture thereby. Again, a hoed crop that would require stirring of the soil late in the season is not desirable. The digging of a crop of potatoes would be, in effect, not unlike plowing the land. If this should be done in September or October, it would be likely to start the trees into a late fall growth which might not ripen up before cold weather.

The most desirable crops for inter-planting are those which call for thorough tillage until mid-summer and at the same time do not interfere with the growth of the trees. If corn is planted, a row or two should be omitted in line with the trees so that as the corn reaches maturity, the trees will still have all the light and air necessary for their best development. For the past two years, in Western Maryland, many of the peach growers have been planting cantaloupes in their young orchards, with very pleasing results so far as the orchards are concerned.

As a rule, when the orchard has reached the bearing age, no other crop should be planted among the trees, at least, not unless the land is heavily fertilized; even with liberal feeding it is a doubtful practice in most cases, on account of a probable lack of sufficient moisture to properly develop the peach crop and the inter-planted crop at the same time.

FIG 12—Good tillage.

## TILLAGE AND COVER CROPS.

*Tillage:*—Comparatively few of the Maryland peach orchards are cultivated sufficiently to accomplish the full end of tillage. The majority of the orchards are plowed in spring, perhaps harrowed two or three times and then allowed to dry out and bake down for the remainder of the season. Many orchards are given no cultivation after the spring plowing. But as a rule this is not sufficient to insure the best results. Let us consider what the result of good tillage is likely to be. Briefly summarized they are as follows:

(a) It conserves the moisture.
(b) It improves the physical condition of the soil.
(c) It sets free plant food.

A brief discussion of these subjects may throw more light on the matter of tillage.

Tillage does not add moisture to the soil but it greatly retards the drying out of the moisture already in the soil. Thorough cultivation provides a layer of light, loose, very finely pulverized earth on the surface of the land. In other words, it makes a surface mulch of earth. Now it is a common observation that ground beneath a light covering of sawdust, straw or some other material is always moist even in a severe drought. The covering has merely checked evaporation of the moisture that was already in the soil. A mulch of finely pulverized earth such as is made by good tillage, acts in precisely the same manner.

Again, if the surface of the ground is light and loose, the rains which come during the summer months will, for the most part, at once soak into the soil. If the ground is allowed to bake down and the surface become hard, much of the summer rain is lost by surface drainage.

Orchard trees suffer more, directly or indirectly, from a lack of moisture than they do from a lack of plant food, though they often suffer from the latter. It is seldom that sufficient rain falls during the summer months to maintain the demands of orchard trees. The conservation, then of the moisture which goes into the soil when the trees are not making heavy demands upon it, becomes a most important factor in orchard management.

By the physical condition of the soil we mean its texture—whether it is hard or mellow, coarse and lumpy or finely pulverized, etc. Mellow, well pulverized soil provides a much larger feeding surface to the roots of plants than lumpy soil does; it is warmer and dries out earlier. Tillage augments these conditions.

In nearly all soils there is an abundance of plant food to produce maximum crops but it is locked up in such chemical combinations that it cannot be used for growing plants (Grass contains all the elements necessary for the food of man but in such form and combinations that they are useless as such.) This locked up food material in the soil can be made available for the use of plants only by the taking place of chemical changes. The conditions existing in poorly tilled soils are such that these changes occur very slowly. But even under the best conditions engendered by tillage, plant food is seldom set free in quantities sufficiently large

to meet the demands of orchard trees for their maximum crops; hence the necessity of applying fertilizers of some sort from time to time. But this will be referred to later.

The soil, when in productive condition, is a seat of great chemical activity; a soil not conducive to such activity is "dead," inert, and unproductive. Good tillage augments chemical changes in the soil.

The preceding remarks relating to tillage are intended to call attention to the principles of the operation. The detail of the actual work must rest with each grower; and when he has clearly in mind the objects to be obtained, the application of the principles should not be a difficult matter.

Other things being equal, that tillage is best which begins as early in the spring as the land can be worked and continues until mid-season, being repeated frequently enough to maintain the surface of the soil in a light, loose condition. Keep the surface mulch in good repair. Many of the Maryland orchards can be given such tillage without difficulty so far as the character of the land is concerned. I am well aware, however, that in the Western part of the State, especially in the mountain orchards, there are conditions which render thorough tillage difficult. Yet even here, every effort possible should be put forth to prevent undue evaporation of the moisture.

But tillage may be overdone or done at such a time that it will do harm rather than good. A clayey soil should not be worked when it is too moist.

*Cover Crops*:—The growing of cover crops,* in orchard management, is so ralated to tillage that one should be treated in conjunction with the other.

The man who remarked to the writer that he thought the soil was all worn out cultivating it so much, may not have been very far wrong. Land which is bare, most of the time, as in the majority of peach orchards in this state, and worked more or less, gradually looses its humus;|| the texture of land lacking in humus is poor and correspondingly unproductive. This difficulty can readily be overcome by a judicious use of cover crops.

There are two classes of cover crops—the leguminous and the non-leguminous. The former consists of such plants as the various clovers, cow peas, vetch etc; these plants have the power of storing up nitrogen from the air so that when they are worked into the soil, the soil is actually richer than it was before. Of the non-leguminous plants used as catch crops, rye is perhaps the most popular of any, though a long list may be used for this purpose. The plants of this class do not add plant food to the soil aside from that which they have taken out in their growth, but they protect the soil and add humus to it upon decay. Cow peas are used in Maryland for cover croping, with more general satisfaction than any other plant; crimson clover has proven satisfactory with some but the uncertain-

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*Cover crop, catch crop and green manure crop are terms used interchangeably.

||Humus, decaying vegetable matter, organic matter, are synonymous terms.

ties of getting a good stand render it of doubtful value for general use. But where it can be relied upon, it is one of the best catch crops for orchard purposes.

The cover crop is of value in a number of ways. The following are some of them :

(a) It adds humus to the soil.
(b) It increases the nitrogen in the soil if it is a leguminous crop.
(c) It may take up nitrogen late in the season, when it would otherwise be lost by leaching.
(d) It increases the moisture-holding capacity of the soil.
(e) It may prevent injury to the trees by severe freezes when ground is bare.
(f) It prevents the running together of hard soils.
(g) It improves the texture of the soil.

Of the various points mentioned, perhaps the improvement of the physical condition of the soil by the addition of humus is the most important. A soil devoid of organic matter is in poor physical condition and regardless of the amount of plant food it may contain, is unproductive. By growing some crop in the orchard each year to turn under, the supply of organic matter can be maintained. I am fully convinced that many orchard lands in Maryland are deficient in this particular. As before stated, the repeated working of the soil, as by tillage, depletes the supply of humus and it is for this reason that tillage and cover crops have a somewhat intimate relationship. Soils well filled with decaying vegetable matter retain moisture much better than soils do that are deficient in this respect.

The ideal tillage has already been described. At the last cultivation, —say the middle of July—the cover crop ought to be sown. The trees have completed most of their growth by this time and do not require as much plant food as earlier in the season so that taken by the growing catch crops will seldom be required by the trees if they have had an abundant supply earlier in the season.

Under favorable conditions the plants used as catch crops will make considerable growth by the time cold weather sets in. The cover should be allowed to remain on the surface of the ground during the winter to protect the land; to hold the snow from blowing off and prevent the rains from washing. Even a cover like cow peas which is killed by the frost should not be plowed under till spring. Then with the opening of spring the orchard may be given a shallow plowing and tilled thereafter frequently enough to keep the soil mulch in good condition, until midseason comes again. By such management as this, a good physical condition of the soil can be maintained and this is exceedingly important in the fertility problem.

## THE FERTILIZER QUESTION.

As already stated, the texture of the soil is a most important factor in considering this question—more important, in fact, than a question of mere plant food, although for maximum results the application of the

latter is more frequently necessary than is usually supposed. So far as I know, no efforts have ever been made to determine accurately the exact amount of plant food required by peach trees in developing a normal crop of fruit. Such a determination has been made for the apple and it has been estimated* that for a period of 20 years between the ages of 13 and 33 years an acre of apple trees (35 trees) bearing for this period, an average of from 10 to 12 bushels annually would take out of the soil in fruit and foliage nearly $80.00 worth of plant food more than an acre of wheat in straw and grain would take out for the same period producing 15 bushels to the acre. This estimate was made on very carefully collected data. Such facts emphasize the necessity of fertilizing apple orchards if the best results are expected. While the amount of plant food demanded for a crop of apples cannot be taken as a guide for the fertilizing of peach orchards, it should emphasize the fact that fruit trees in producing large crops of fruit make a heavy draft on the food supply in the soil. If this food is not available then the crop must necessarily suffer.

As to the amount of fertilizing material that should be applied to peach land, no specific advice can be given. Each orchard presents a different problem. It all depends upon the condition of the soil, and what plant foods it already contains. However one or two suggestions may not be out of place. In practically all cases, the nitrogen should be supplied by the use of leguminous cover crops. This has already been discussed in another place. Trees that are making a vigorous growth with dark green foliage are generally well supplied with nitrogen; but if the foliage is yellowish and the trees are free from borers and disease, it is safe to conclude that they lack nitrogen.

The demand for phosphoric acid and potash is generally best met by securing the chemicals separately and mixing such proportions as the case in question seems to demand. Generally speaking, in fruit growing, potash is the more important of these two food materials, though in growing the cereals and general farming this is true of phosphoric acid. Potash is supposed to influence in an essential manner the fruit acids, the sugar content and the flavor; prabably, too, fruit well supplied with potash will color up better than when it is lacking. This must not be construed to mean that phosphoric acid is not essential also. On fairly productive lands, well supplied with nitrogen in the manner above suggested, from 300 to 500 pounds per acre of muriate of potash and South Carolina Rock or some other standard forms of potash and phosphoric acid, may be a fairly good application though this reference to the amount applied should be considered merely as a suggestion. The point is, as much should be used as can be applied profitably. If the application of a half ton will make an orchard produce enough more than 500 pounds to more than pay for the additional amount, then the half ton is none too much. The only way this matter can be determined is to actually try it and note the results.

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*Cornell Experiment Station Bulletin No. 113.

F "Leggy" trees. Judicious pruning would have made them more stocky.

## SUGGESTIONS ABOUT PRUNING

No two men have just the same ideals, and as a result no two peach growers will prune and shape their trees in just the same way; custom, too, in different peach growing sections is a potent factor in regulating many orchard operations. For instance, in Western Maryland the usual practice is to head the annual growth every year until the trees have reached the bearing age. On the Eastern Shore the young trees are seldom cut back at all. This difference in method seems to be more a matter of long practiced custom in the different sections rather than because there were any fundamental differences between the two peach growing sections referred to.

Peach trees that have been well cared for until they are four or five years old, seldom require heavy pruning thereafter. The dead branches should be removed or where limbs cross each other or in any way interfere one with another, one of them ought to be removed. Then, too, if the trees are in fertile soil, the tops may become so thick and bushy that the sunlight and air do not have free access to the fruit. The tops should be kept open; the fruit will color up and mature better when this is the case. A little attention given the trees each year, will keep them in good shape. In cutting off limbs, the wounds should be made as smooth as possible and no long stubs should be allowed to remain. A stub will never heal over, while if cut off as close as possible to the main limb

healing will rapidly take place. A sharp saw is the best implement for removing limbs too large to cut off with pruning shears.

Heading in during the first three or four years of the life of an orchard is practiced by many of the most successful growers. It has many things to commend it when judiciously done. The main limbs which form the top of a peach tree, if allowed to grow unchecked, have a strong tendency to become long and slender. This results in their being easily broken down under the weight of fruit which is borne near the extremes of the limbs. Then, again, the trees will grow so tall that picking the fruit becomes a laborious matter, and more expensive than need be if the trees are not permitted to grow so tall and "leggy". Heading back half, more or less, of the annual growth, every year until full bearing age is reached will tend to make the trees much more "stocky"; there will be much less tendency for the trees to become leggy; much of the fruit can then be picked from the ground and consequently more quickly and cheaply than where a good deal of it must be picked from laders or the branches pulled down with hooked sticks where they can be reached.

More or less thinning of the top will usually need to follow heading back. If this is not done the top may become unduly thick and bushy·

Heading back will seldom be necessary or advisable—unless for special purposes—after the trees come into heavy bearing. In a word judicious pruning may make the trees more stocky and therefore better able to withstand the weight of a heavy crop of fruit; it will make the top open; give free access to air and sunshine. It will also thin the fruit, an operation next to be considered.

## THINNING THE FRUIT.

This operation is much recommended; is favored by many of the growers but as a matter of fact, is not generally practiced, though it is done more in some sections than in others.

A peach tree, under normal conditions, will assimlate a certain quantity of food material during the time it is developing a crop of fruit. Peach trees are inclined to over bear, that is, set more fruit than they can properly mature with the amount of food material it is possible for them to assimulate. Hence it is that the fruit all remains small, not reaching the size that will bring satisfactory prices in the markets. Thinning the fruit will reduce the strain upon the tree; there will be, so to speak a smaller number of mouths to feed, and the remaining fruit will be correspondingly larger. As the severest strain upon the tree is occasioned by the development of the seed, the thinning should be done before the seed begins to harden; this will be while the fruit is still quite small. It will be safe to begin as soon as the "June drop" is passed.

The objection that many hold to thinning is the expense of the operation. But unless there are severe storms, very little of the fruit which remains on the tree after the "June drop" will fall off. It then follows that it is only a question between picking the fruit off in June and throwing it on the ground and picking it off a little later and putting it in a basket.

If the fruit is thinned to from four to six inches apart, it will be

better than if it is closer. It is a common experience that trees so thinned will actually produce a greater bulk of fruit than unthinned trees,and the fruit from such trees is practically all first grade. Even if the bulk of fruit is somewhat less than from unthinned trees the amount of high grade fruit is sufficient to commend the operation. The fruit may be thinned considerably by keeping the tops properly pruned but much of it must be done by hand. In this way, the imperfect fruit can be removed, leaving only that which is likely to develop into the best specimens. This method will greatly lessen the work of grading the fruit when it is marketed.

As a rule growers experience considerable difficulty in getting their men to thin their fruit sufficiently but it is important that the matter be followed up closely.

Desiring to get an expression from one who had thinned systematically, I wrote to Mr. Caleb Long of Boonsboro, asking him several questions about his methods and experience. Mr. Long's reply is given herewith.

BOONSBORO, MD., Dec. 6, 1900.

Dear Sir:—Yours of recent date received. As to the value of thinning peaches, I can only speak in a general way. 1st, It prevents the tree from becoming exhausted from overbearing, thus giving excessive crops. Thinning is quite an advantage in this respect. 2d. It saves the tree from being broken. 3d. In a measure it prevents rot. I have noticed where peaches are clustered together, there is more tendency to decay. 4th. It gives fewer peaches to handle, and more packages of larger fruit and of better quality to market. The result,—a larger bank account in our favor at the end of the season.

In the season of 1898 two trees in a very full orchard were left unthinned as an experiment. As a result the trees were broken to pieces, one being rendered almost worthless; the fruit inferior, at least one-third smaller than the neighboring trees, and not so well colored. The experiment on one tree, one side of which was thinned, the other unthinned, yielded peaches almost twice the size on the part that was thinned.

The thinning should be begun early, as soon as it is evident that the fruit is too heavily set. I am convinced that the earlier the work is done the better will be the results.

Method. Two men at each row, both starting at the same place and going around the tree in opposite directions until they meet opposite the point from where they started. Someone or yourself to look after the work to see if each man does his work properly. The trouble I have found is to get men to thin enough.

Distance. Where fruit is heavily set, six inches apart on the same limb is as close as they should be left. 800 peaches is enough for any tree to bear. That amount on a large tree would appear very thin. Cost. Well, that depends. Large trees, very full, will cost about six cents per tree. I would think, from my experience, that four cents per tree on an average is a liberal estimate for the average orchard. It is claimed that it is money thrown away but like "Bread cast upon the waters," it will return not many days hence.

Respectfully,

(Signed) CALEB LONG.

Mr. Long is one of the most successful peach growers in Western Maryland and speaks from long experience. The results of thinning are not all manifest in the year the work is done. The crop the following year is improved also from the fact that the trees have not become exhausted by overbearing the previous year. In Utah it was found in 1898

and 1899, the trees that were severely thinned in 1897 could readily be picked out by their larger and more evenly distributed fruit. There can be no doubt about the advisability of thinning when the trees are heavily laden. No operation in the orchard will pay better returns than this. The fruit is better in size, color and in other ways which enter into the requisites of a *first class* peach.

## MARKETING THE PRODUCT.

Many well grown crops of fruit are rendered unprofitable through faulty methods of marketing. This may be due to a variety of causes but is largely the result of a lack of knowledge on the part of the shipper of just what the market demands and of the manner in which the fruit should be prepared for shipment. Then, too, there is often a difference of opinion between the shipper and market, in regard to just what constitutes *first class* fruit. Their standards are not the same, and usually that of the market is the higher of the two. What the shipper calls first class fruit, falls below that grade when judged by the market's standard. This difference is the cause of much annoyance and disappointment.

The first essential is to grow first class fruit. This cannot be done on poor trees growing in poor land. The fruit must be carefully graded as to size and quality. Not a single fruit bearing a blemish of any kind should be permitted in a first class package, and it should be of uniform size and sufficiently large to meet the demands of the market. In whatever style of package the fruit is packed, it must be honest measure, and so placed that there shall be no movement of the individual fruits in transportation. If any "rattling" occurs the fruit is apt to be bruised thereby and rendered unfit for market.

The style of package should be regulated by the taste of the market for which the fruit is intended. Some styles "take" better in certain markets than they do in others. But whatever the style, due regard should be paid to the character of fruit which is placed therein. For instance, the buyer expects fruit of a high grade in a six basket carrier; also in a twenty pound basket or one-third bushel basket. In this, however, he is frequently disappointed. During the past season, the writer saw in the Philadelphia market, fruit packed in six basket carriers that ought never to have been shipped at all. In this way, the "carrier trade" is being destroyed. And whose fault is it? The market is seldom glutted with high grade fruit; the over-stocking is generally due to the abundance of fruit that on account of its quality, does not meet with a ready sale. As a rule, there is but a very slight margin of profit,—often an actual loss,—in the shipment of such fruit. It is a rare occurance, when first class fruit, properly packed, fails to bring profitable returns. The freight rates and nearly all the other expenses are as great on poor fruit as on the fancy grades. The moral herein contained is plain.

Growers frequently ship to several commission men in the same market. My attention was called the past season to a Maryland grower whose shipment on a certain day consisted of 40 packages of peaches. These went to seven different commission houses in the same market. If this fruit was of uniform grade it was simply competing against itself from seven different points. If two grades of fruit are being shipped to

the same market, there may be no disadvantage in shipping the different grades to different parties, but if the shipment is of a uniform grade it is generally unwise to ship to more than one commission house in the same market. As a rule, it will be more satisfactory to deal with a single reliable commission man (there are more of them than some are inclined to believe) in the various markets and to establish a reputation for careful grading and honest packing. Such a reputation being made, the fruit is often sold before it arrives in the market and frequently at a higher price than could be obtained if it were necessary for the commission man to wait until after he could see the fruit before daring to sell it. An overstocked market may thus be escaped by selling earlier in the day.

The shipper ought to get in the closest touch possible with his commission man and market conditions generally. An occasional trip to the market into which he is shipping will pay a grower many times over.

Several commission men were asked to make suggestions from their point of view, whereby the market demands might be better complied with and the following replies have been received. The suggestions are pertinent and should receive due consideration.

PITTSBURG, PA., Jany. 25th, 1901.

Mr. H. P. Gould, College Park, Md.

Dear Sir:—Replying to your circular letter of Jany. 24th, in which you request suggestions regarding improvement in the manner in which Maryland peaches are placed upon the market, beg leave to state, that this firm is very much in favor of a uniform package and also a uniformity in the grading of fruit for this market. The best seller on this market is the 6 basket carrier for fancy fruit, but for No. 2 fruit, or culls, we would suggest bushel boxes. It seems to us that if a uniformity in packing fruit was considered, and each shipper adopt the same style packing, it would prove very beneficial to all concerned. The shippers would then receive top market prices for their fancy fruit and also a fair remuneration for their No. 2's or culls. We are very much in favor of a uniform package for shipping fruit to this market.

Trusting the information given will be of use to you, we remain,

Yours very truly,

(Signed) IRON CITY PRODUCE CO.

BALTIMORE, Feb. 18th, 1901.

H. P. Gould, Esq., Asst. Entomologist and Asst. Horticulturist,
Maryland Agricultural College, College Park, Md.

Dear Sir:—Replying to your letter of the 24th of January proximo, asking if I can give you any information or make any suggestions regarding the marketing of our Maryland peach crop, I beg leave to state my opinion based on an experience of some thirty years in this line, in receiving and selling on commission peaches from all sections of this state. The consumption of the larger portion of the peach crop of Maryland differs materially from that of any other State, as the bulk of the crop goes into cans, packed by the large packing houses of our city, so that, while for this large percentage of the trade the fruit should be well matured. it is necessary that it should arrive in a firm condition, but not mellow, as would be desired for table use. The large proportion of peaches used by our packers is shipped to our city from the tributaries of the Chesapeake Bay, both from the Eastern and Western Shores. Until within the past two or three years all of the peaches from these sections were shipped in boxes, but not of uniform size. The Western Shore (that is, from Anne Arundel to south) and Kent and Queen Anne's Counties on the Eastern Shore, using mostly the standard box, 8x14x22 in the clear, while Talbot County, Dorchester

and other Eastern Shore counties used a variety of sizes from 6x12x18 to the standard size.

Much objection was raised by the packers to these irregular size boxes and about three to five years ago growers in the sections above referred to commenced using 5-8 baskets. These took well so long as they were what they were claimed to be—5 8 –but by all kinds of deceptions, optical delusions, such as thick bottoms, drawing the slats in, etc., the basket maker. encouraged by the grower, has gotten them down so that nine tenths of the 5-8 baskets will not hold over 4 8 and a few not even that quantity.

Now, all this is wrong and in the end a detriment to the grower. What should be adopted by our Southern Maryland peach growers, who know nine-tenths or more of their crop is going to be sold to the packer, is a uniform package. If a box, have the heads and centre-piece 8x14 with slats 24 inches long, making 8x14x22 inches in the clear. If in baskets, use the full 5 8 Delaware basket. My impression is that the box is preferable to the basket They can be much more easily handled from the orchard to shipping-point and also in transportation. The fruit does not get mashed and tumbled about in the boxes as it does in baskets. All shippers of peaches in open baskets know how the peaches get mashed in piling them up, first, on the wharf from which they are shipped, then in piling on the boats and again unloading from boats to docks here. Every handling necessarily results in mashing some of the best peaches on top of the baskets.

There is one strong argument in favor of boxes over baskets for shipments from sections named above, which, no doubt, has never occurred to the shipper. It is this: two thousand baskets of peaches piled on any of our piers here will make as big a show as five thousand boxes and yet have only one fifth the actual quantity of peaches. Now, the consequences are that the buyers for the packing houses go on piers on Light St. and see them piled up with baskets and the impression is formed at once that there is a tremendous quantity and they must buy cheaper, when if the same quantity of peaches were in boxes they would occupy not to exceed one-fifth of the space on the same pier and the opposite impression would be formed in the minds of the buyers and, I think, better average prices would prevail.

My remarks so far have had reference to the marketing of peaches from the southern counties of our state, the receipts of which are almost entirely by steam and sail vessels. I have, however, already consumed so much of your space that I feel inclined to stop here, but a few suggestions to a very important and growing section of our state (Western Maryland) would not be amiss. The marketing of peaches from this section differs materially from that of Southern Maryland, as their sources of distribution are so much greater than that of Southern Maryland. They are not dependent on Baltimore alone for a market, as solicitors and buyers are located with them from nearly every large city during the shipping season, and their peaches are, and should be, packed more with a view of going into family consumption than packing houses. For this reason more care is necessary to be exercised in gathering and packing them than in the southern counties of our state.

The fruit should be allowed to hang on the trees until it obtains its full size and ripeness; then it should be carefully picked, avoiding bruising, and carefully graded, as to size and color. I should advocate the packing of the best grades (and the best only) in the six basket carriers; the second grade in $\frac{5}{8}$ baskets with tops and the third grade in the 7 inch box usually used in that section.

I do not think it necessary to enlarge on this subject as every Western Maryland peach shipper will readily see the advantages to be gained by the adoption of these suggestions. I will merely add that it is money wasted to put poor fruit in six basket carriers. Buyers always look for something fine in these packages and turn away with contempt if on opening a sample they find ordinary or poor fruit.

I must, however, draw this article to a close, as it is already longer than I intended.

Yours truly,

(Signed) WALTER SNYDER,
Prest. of The Snyder & Blankford Co.
Baltimore.

NEW YORK, Feb. 26, 1901.

Mr. H. P. Gould, College Park, Md.

Dear Sir:—Your favor of February 18th came duly to hand. We find it impossible to devote the time to make such an article as would be of much assistance to you.

We would say in brief that peach growers must realize the vast importance of raising fine quality peaches to obtain a profitable market. Owing to the very large quantity of this fruit which finds its way to market, beginning with shipments from Florida and followed by the beautiful varieties and quality from Georgia, the standard of grade is advanced each year, and consumers are now educated to the possibilities in raising this fruit, and medium and inferior grades are neglected for direct consumption; by this we mean that a certain quantity of the crop will always be of more or less inferior grade, which can be consumed through the process of evaporation, or by canning for the later markets, but for direct shipment to the selling markets, only fine well colored perfect fruit should be sent.

The improvement in quality of fruit has been closely followed by improvements in shipping methods. The refrigerator car has now become an absolute necessity from shipping points, whose product cannot reach the market inside of 18 hours. The package most profitable for shipment is the one which will carry the fruit in the best possible condition and present a most pleasing appearance. Growers should always keep in mind that for profit it is necessary to to please the eye of the buyer. A fine appearance always attracts attention, and the flavor and other merits are presumed to be there when the appearance is attractive.

It is a mistake for growers to feel that any package will improve the quality or enhance the value of their product. The best package in general use at the present for fine fruit is the 6 basket carrier, because it usually carries the contents to market in perfect condition, but unless the fruit is of the very best quality, it cannot present an attractive appearance, and at once becomes an unprofitable package, because all of the imperfections of the fruit can be seen at a glance, instead of the buyer being pleased with appearances he is repulsed, therefore where it is necessary for growers to ship a crate below fancy, almost any other package than a carrier crate would be more profitable. As to varieties there is no great choice. Any large fully matured finely colored peach is attractive and popular. Growers can best judge themselves of what varieties will mature best in their immediate section. Growers should also keep in mind that the best market for highly perishable fruits, which must be handled quickly, is in the early morning hours. The New York market opens as soon after 12 o'clock midnight as the fruit can be received and offered for sale. It is to the growers' advantage to have their fruit in the market ready for sale not later than 2 a. m., when all the advantage of the market can be had. There is no hard and fast rule as to what is the best selling time, but the merchant having the goods for sale will exercise his judgment as to the best selling time, so that if he has fruit in his store he is ready to take advantage of all opportunities. He may find it to his advantage to hold the fruit until some later hour, but from past experience the early morning hours are the most profitable for selling, as all buyers are then seeking a supply.

Any information we can give you, will be very cheerfully forthcoming. We are,

Yours respectfully,

(Signed) J. H. KILLOUGH & CO.

## GENERAL TREND OF THE INDUSTRY.

There is nothing stable about peach growing. There are sections in Maryland once famous for great production of fruit, that now possess only here and there a dilapidated orchard. In all of the extensive peach growing sections of the state, the industry is even now waning. Tens of thousands of trees have been rooted up within the past six or eight years. At the same time the industry is being gradually developed in new areas with good prospects of success.

In all the well known peach areas there has been a time of very extensive planting, followed by a period of little fluctuation so far as the extent of operations were concerned. Then has come a decline of the industry. Some of the peach growing sections of Maryland are now in this latter stage of their evolution.

Methods of handling the fruit also change. The styles of packages that were most acceptable ten years ago have, in many cases, been superceded by others. New varieties are constantly being introduced, though a large number of the most popular kinds of today, have been in cultivation many years. Popular taste and fancy are also factors which vary more or less from year to year. It should be the aim of the shipper to keep in touch with all of these changes. He should aim to supply what the consumer wants and in the way he wants it. It is only by thus catering to popular demand that the highest prices can be expected.

## NOTIONS REGARDING CAUSES OF FAILURE.

There is almost a universal complaint among Maryland peach growers that peach growing is no longer profitable. In many places the notion is current that the trees will fail before they have reached the age of full bearing. With these conditions prevailing, something must be fundamentally wrong. It was not always thus. We have given this phase of the peach growing industry much careful thought and consideration.

For the sake of the masses it may be fortunate that the fabulous prices obtained in the early days do not prevail at the present time but a reasonable profit to the grower ought to be realized. I believe that many of the obstacles in the way of success can be overcome. It is a significant fact that many orchards here and there are proving satisfactory; the trees bear well; prices obtained leave a fair profit; the owners are making no complaint. And these are the orchards, which, as a rule, are given the best care, and the most business-like management.

The fertility question, already discussed, is a most important factor in this connection, more especially as it involves the physical condition of the soil. I confidently believe that there is a lack of decaying vegetable matter in many of the Maryland peach lands. The most of these soils are bare the greater part of the time, except for weeds, and as a rule nothing is put on to add humus. As a natural consequence the vegetable matter in the soil must become exhausted. Such soils are unproductive. Methods of improving this condition have been discussed under "cover crops." But I am convinced that a lack of available plant food causes a surprisingly large number of failures. In all parts of the state there may be found orchards that give every evidence of this. A yellowish, stunted condition, with the trees making but little growth is suggestive of an insufficient food supply. This condition is frequently mistaken for "yellows" and the accidental fertilizing of such trees has many times given rise to the notion that such treatment will cure the "yellows." It will cure "starvation yellows"!

In many cases the system of orchard management will admit of improvement. Many orchard lands, after being planted, are severely cropped for three or four years. The owner expects as much from the interplanted crop as if the peach trees were not occupying the ground. He forgets that

he is practicing a system of double cropping and fertilizes for only one crop, or none at all in many cases. When the trees are three or four years old they may bear considerable fruit; the fourth year, if conditions are favorable, a heavy crop is probably produced. During the previous years, there has been little or no vegetable matter added to the soil; its available plant food has been drawn upon to produce the tree and the inter-planted crops. The production of this heavy crop of fruit, under these conditions, becomes a severe strain upon the tree and on account of exhaustion, it may be two years before another crop is produced; or if the fruit sets, the trees being exhausted, nearly all of it falls in the "June drop." Perhaps, too, by the time the trees have recovered enough to produce a crop it is destroyed by adverse weather conditions. Thus the trees may be seven or eight years old before they bear a second profitable crop. Meanwhile nothing has been done to enrich the land and its physical condition has been growing poorer all the while. The second crop draws heavily upon the strength of the trees and another long period of recuperation is necessary. By this time, disease, borers etc., have made their inroads and the orchard, too, has reached the age where its decline may soon be expected. Such an orchard "goes out" and the owner avers that peach growing is unprofitable!

This is not the "life history" of any particular orchard but it represents a condition that is far too common. The remedy is suggested in the foregoing discussions. Many of the old time orchards referred to, whose records seem phenomenal, were systematically pruned and heavily fertilized in such a manner that the texture of the soil always remained good. Enough has already been said about thinning the fruit and the market problem to emphasize their relations to the economy of orchard management..

Of course, disease and insects have been active factors in the failure of many orchards, but where these obstacles are squarely met, it is seldom that there is much to fear. So far as the "yellows" is concerned, the well-known experience of the growers in Michigan ought to contain its own impressive lesson for those in Maryland who are suffering in a similar way. Many trees are killed by borers and more are severely injured, but there are no short cut methods of overcoming them. The digging out process is the only efficient remedy and this is frequently neglected. The yellowing of the foliage due to borers is very often mistaken for the "yellows."

Again, following the period of very general planting, it is only a natural consequence that a considerable portion of the orchards should prove unprofitable. When it became, in various sections, almost a "fad" to plant peaches many put out orchards who had no inclination or fitness for growing fruit. The money factor was the only inducement that led them to plant the orchards. The fact does not necessarily portend failure, but in many cases it follows. On the other hand, the one who loves fruit growing—and it is true in any business—is more likely to succeed than the one who sees nothing in his work beyond the dollar. He will, as a rule, give better attention to his orchard, and other things being equal, the better the care, the greater the profit. In other words, the man is a most important factor in fruit growing.

As a rule, a small orchard, thoroughly attended to will prove more profitable, in the long run, than a larger one that receives only indifferent care. The majority of the Maryland orchards are on farms where mixed husbandry is practiced, and it is frequently the case that the orchard is given attention only after the other work is done; it often suffers thereby. A reduction in the size of the orchard, in many instances, would help solve the problem.

The notion is more or less current that there have been recent climatic changes which have made peach growing more uncertain and difficult than formerly. Hoping to get some light on the matter, an inquiry was sent to the Climate and Crop Service of the Weather Bureau asking for infarmation. In replying to my letter of inquiry, the Section Director, Mr. F. J. Walz, made the following statement: "I will say that from all the data that I have examined I do not see any reason for the statement, and to a large extent, belief, that there has been any change in the temperature or amount and distribution of rainfall in this state during the past century." Mr. Walz makes this statement after having examined and studied all the available climatic data for the state.

There are five cardinal points in fruit growing; the man with tastes adapted to it; the location; the proper selection of varieties; maintenance of soil fertility; good business sagacity in marketing. For most orchard fruits, a sixth point, spraying, should be mentioned and even for peaches there are many times when it can be confidently recommended. These various points admit of almost infinite subdivision to cover the detail of orchard management. Wherever each one of these factors is being given due weight and consideration in the economy of peach culture, the growers, as a rule, still maintain that "there is something in peaches."

NOTE:—The subject matter of this Bulletin is intended only as a preliminary study of the peach growing industry of the state. To make the work complete, more extended observation is necessary and many problems can only be solved by carefully conducted experiments One of the most important lines of effort is in the determination of the adaptability of varieties to local conditions. The writer will be glad to have the growers carefully note the behavior of different varieties in their sections and report to him from time to time, concerning their adaptability to the conditions under which they observe them. Any manner of co-operation in this work will be appreciated.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 73. April, 1901.

# SUGGESTIONS ABOUT COMBATING THE SAN JOSE SCALE.

By H. P. Gould.

## INTRODUCTORY STATEMENTS.

There is still a demand for much elementary instruction regarding the San Jose scale; especially is this true concerning methods of combating it. It is evident that the treatment must be governed to a certain extent by conditions that are more or less local. For instance, some of the methods that have been successfully used in California are not recommended in the East and the treatment that is generally advised for Maryland conditions does not give the same satisfaction in Canada. This variation is probably due to differences in the climate.

The experiences in Maryland in combating this pest have been varied and the success of the different lines of treatment has been equally so. From these experiences, however, we are able to glean facts of great value in outlining the methods that seem to be the most effective under the conditions that exist in this state. But we cannot yet say that a thoroughly satisfactory mode of procedure has been determined. Some of the recommendations which were commonly given two or three years ago are seldom made now, from the fact that, in the light of more recent experience, other lines of treatment have proven more effective and satisfactory. In the same way, it is altogether probable that future efforts may develop better methods than those now in vogue.

Probably kerosene has been used more extensively in the East than any other single material in combating sucking insects, of which the San Jose scale is one. It is of special value on account of its effectiveness; its comparative inexpensiveness and the ease with which it can be procured; yet kerosene has its failings as an insecticide. Its physiological effect on plant life is sometimes disastrous but many of the limitations of its use are now well known so that one can, as a rule, guard against probable danger of injury therefrom in applying it.

One of the most important factors to be considered in this connection is the condition of the tree to which the kerosene is applied. Many conflicting results have been obtained in the use of kerosene, it doing serious harm in some cases and none in others. In many cases, at least, differ-

ence in the condition of the trees at the time the applications were made will account for the apparently conflicting results. This fact has been emphasized in several instances in this state. Some substances used for insecticidal purposes can be applied stronger when the trees are dormant than when they are in an active state and it has commonly been supposed that this was true of kerosene but the contrary is the fact. Late in the fall of 1899, after the trees had become perfectly dormant, a large number of peach trees were sprayed in Washington and Kent counties with a 20% mechanical mixture of kerosene and water. This spraying was done for practical purposes, not in an experimental way. But with the advance of the following spring (1900) the trees sprayed the fall before showed evident signs of serious injury. The fact soon developed that the trees were completely killed by the treatment except here and there a branch which presumably had escaped the spray.

During the winter no spraying was done but about the middle of March it was begun again. From this time until the blossoming period many hundred trees were given the 20% mixture. Practically no harm resulted from this treatment. It was only here and there that a bud was killed and an occassional limb showed some injury. The effect on the scale was, in most cases, all that could be expected. A single case may be cited. A recent examination (March 1901) of some trees that were sprayed a year ago, showed almost an entire absence of the insect. The trees were badly infested when given the treatment.

The serious results of spraying while the trees were dormant opened the question of summer treatment. For the most part the experiments now to be referred to in the different sections of the state were duplicates in as much as it was thought that the climatic differences might be a factor entering into the results. This, however, does not seem to be the case within the limits of climatic variation under which the work was done.

## EXPERIMENTAL NOTES.

The object of these experiments was to determine, so far as possible, the effect of the different percentages of kerosene on the trees as well as on the insects during the active growth of the former. To make the work practicable it was necessary to determine a percentage that would kill the insects and not materially injure the trees. It ought to be said that these points had previously been worked out more or less definitely for some kinds of trees in other states but the important point at issue was the percentage that could be used on peach trees in Maryland.

### SERIES I. KENT COUNTY, JUNE 6.

Weather bright and warm, light breeze.

(a) 5 peach trees sprayed with 10 per cent kerosene.

(b) 6 peach trees sprayed with 20 per cent kerosene.

*Results:*—June 27, these trees were axamined. The foliage on the ones receiving 10% was slightly injured and a few leaves had dropped. The most of the injury consisted in burning the edges of the leaves but it

was not severe enough to be a matter of serious consequence. Many of the insects were killed but not all of them.

The 20% kerosene injured the trees only slightly more than the 10% with the exception of one tree where from one-fourth to one-half of the foliage dropped. This tree did not seem to be as vigorous as the others were. Only two or three live insects could be found.

SERIES II. CHARLES COUNTY, JUNE 20.

(a) 2 peach trees sprayed with 5 per cent kerosene.

(b) 2 peach trees sprayed with 10 per cent kerosene.

(c) 2 peach trees sprayed with 15 per cent kerosene.

(d) 1 peach tree sprayed with 20 per cent kerosene.

(e) 1 peach tree sprayed with 25 per cent kerosene.

In addition to the trees that were sprayed with kerosene there were others treated with a tobacco-whale-oil soap solution as follows:

(f) 1 tree sprayed with soap solution, 1 pound to 1 gallon of water.

(g) 1 tree sprayed with soap solution, 1 pound to 3 gallons of water.

(h) 1 tree sprayed with soap solution, 1 pound to 6 gallons of water.

(i) 1 tree sprayed with soap solution, 1 pound to 6 gallons of water and 10 per cent kerosene combined.

*Results:*—The condition of the trees was noted from time to time with the following final results as observed July 9.

(a) 5 per cent. No apparent injury to foliage; insects not affected by treatment.

(b) 10 per cent. Leaves slightly injured but hardly noticeable; many insects killed, though living ones are abundant.

(c) 15 per cent. Foliage injured more than (b) but not seriously; a very few leaves have fallen. Nearly all insects are dead.

(d) 20 per cent. A little more injury to the foliage and more of it has fallen than in (c) but not enough injury to be of serious consequence; insects apparently all dead.

(e) 25 per cent. Not materially different from (d).

**SOAP SOLUTIONS.**

(f) 1 pound to a gallon of water. From 10 per cent. to 25 per cent. of foliage has fallen; the leaves remaining on the tree show but very little injury. Insects apparently all dead.

(g) 1 pound to 3 gallons. Injury to foliage very slight if any; insects appear to be unaffected by the spray.

(h) 1 pound to 6 gallons. Not unlike (g).

(i) 1 pound to 6 gallons combined with 10 per cent. kerosene. No apparent injury to leaves; nearly all insects seem to be dead.

### SERIES III. WASHINGTON COUNTY, JUNE 22.

Weather bright, clear, sun very hot, light breeze.

(a) 2 trees sprayed with 5 per cent. kerosene.

(b) 2 trees sprayed with 10 per cent. kerosene.

(c) 2 trees sprayed with 15 per cent. kerosene.

(d) 1 tree sprayed with 20 per cent. kerosene.

(e) 1 tree sprayed with 25 per cent. kerosene.

*Results*:—The final examination made July 14th showed practically no injury to the foliage from any of the applicaiions. The effect on the insects was as follows:

(a) 5 per cent. Apparently no effect.

(b) 10 per cent. Some of the mature insects were probably killed but the young are very abundant now.

(c) 15 per cent. Fairly satisfactory; very few young to be seen and only an occasional adult that is alive.

(d) 20 per cent. Difficult to find a live insect.

(e) 25 per cent. Same as (d).

### *SERIES IV. PRINCE GEORGE COUNTY, JUNE 12.

Weather cloudy, warm and muggy, slight breeze.

(a) 1 tree sprayed with 10 per cent. kerosene.

(b) 1 tree sprayed with 15 per cent. kerosene.

(c) 1 tree sprayed with 20 per cent. kerosene.

(d) 1 tree sprayed with 25 per cent. kerosene.

(e) 1 tree sprayed with 1 lb. tobacco-whale-oil soap to 6 gal. water.

*Results*:—June 26, the trees were in the condition noted below:

(a) 10 per cent. Most of the foliage more or less burned along the edges and spotted. A few of the leaves have fallen.

(b) 15 per cent. Same in character as (a) but more pronounced. More leaves have fallen than in (a).

(c) 20 per cent, About the same as (b). Perhaps slightly more pronounced.

(d) 25 per cent. Not unlike (c) but more of the foliage has dropped and is still dropping.

(e) 1 lb. soap to 6 gallons water. No injury. On June 21st this tree (e) was sprayed again with the soap solution using 1 pound to two gallons of water. On the 26th the leaves showed serious injury; many had

*Series IV, V. VI and VII were intended principally to determine the physiological effect upon the trees.

fallen and the slightest breeze or jarring of the tree still caused them to drop in large numbers. Nearly one-half of the foliage had already dropped. This tree was infested with the San Jose scale but the insects were apparently unaffected by the spray.

### SERIES V. PRINCE GEORGE COUNTY, MARCH 12.

Weather cloudy; temperature about 30 degrees above zero. The spray froze as soon as it came in contact with the trees.

(a) 2 trees sprayed with 20 per cent. kerosene.

(b) 2 trees sprayed with 30 per cent. kerosene.

(c) 1 tree sprayed with 40 per cent. kerosene.

(d) 1 tree sprayed with 50 per cent. kerosene.

(e) 1 tree sprayed with 100 per cent. kerosene (clear kerosene).

*Results:*—(a) 20 per per cent. About one-third of the branches killed; also many buds on the other branches.

(b) 30 per cent. Injury more serious than (a); about one-half the branches killed and also many buds.

(c) 40 per cent. Only one branch alive; many buds on this branch killed.

(d) 50 per cent. Tree practically dead; only a few terminal buds put forth leaves.

(e) 100 per cent. Tree dead.

### SERIES VI. PRINCE GEORGE COUNTY, MARCH 22.

Weather bright and sunny. Temperature about 37 degrees above zero.

This series is a duplicate of Series V. The weather factor enters into the effect of the spray in an important manner. In Series V the spray froze to the trees as soon as it came in contact with them and it was also cloudy. In this series, it was warm and the day bright and clear.

*Results:*—(a) 20 per cent. Injury slight. A few small branches killed but not enough to be taken into serious account.

(b) 30 per cent. Not unlike (a).

(c) 40 per cent. Injury serious; from one-half to two-thirds of top practically dead.

(d) 50 per cent. Injury somewhat more pronounced than (c).

(e) 100 per cent. Practically dead.

### SERIES VII. PRINCE GEORGE COUNTY, MARCH 30.

Weather cloudy; no sunshine. Temperature about 43 degrees above zero. The treatment of the trees in this series was also in duplicate of Series V, the weather conditions being, as in Series VI, the important factor to be considered.

*Results:*—

(a) 20 per cent. Injury slight if any.

(b) 30 per cent. Injury somewhat more pronounced than (a) but not serious enough to be of any consequence.

(c) 40 per cent. Effects of spray not unlike (b).

(d) 50 per cent. Somewhat greater injury than in (b) and (c); a few small branches killed but tree will soon outgrow all appearance of the injury.

(e) 100 per cent. About one-half the buds were killed. One or two branches dead.

It is interesting to note that the results in Series VI and VII are practically the same. The difference in the weather conditions did not seem, in these cases, to be of any material consequence.

## LESSONS TAUGHT BY THE FOREGOING EXPERIENCES.

1. Perhaps the most important fact developed relates to the disastrous results of spraying peach trees with a 20 per cent. kerosene mixture when they are perfectly dormant.

2. A 20 per cent. mixture of kerosene and water thoroughly applied between the middle or latter part of March and the blossoming period gave generally satisfactory results.

3. The tobacco whale-oil-soap solutions are likely to seriously injure the foliage if used sufficiently strong to destroy the adult scale. A mixture of one pound of soap to 6 gallons of water and 10 per cent. kerosene gave good results.

4. Five per cent. kerosene has very little effect on the scale; 10 per cent kills the young and some adults; 15 per cent. kills the most of the insects; 20 per cent. evidently destroys all the San Jose scale with which it comes in contact; inasmuch as 20 per cent is effective, there seems to be no necessity for applying any stronger mixtures.

5. Five per cent. kerosene is not likely to injure the foliage; 10 per cent may cause slight injury to the foliage; 15 per cent and 20 per cent. may produce an increasing amount of injury over the 10 per cent but not in proportion to the increased amount of kerosene used. Trees that are weak from any cause are more likely to be injured by the different proportions of kerosene than good strong trees are.

6. The danger from kerosene used sufficiently strong to destroy San Jose scale, applied any time except when the trees are dormant, is insignificant in comparison to the danger from the scale.

7. Kerosene in a 20 per cent mixture and stronger is much more destructive to peach trees applied when the spray will freeze to the trees than when the weather is warmer. (See Series V.)

8. Practically the same results are obtained when kerosene was applied during cloudy weather as when applied in bright sunny weather. (See Series VI and VII.)

## CRUDE PETROLEUM AS AN INSECTICIDE.

For several years past this material has been used more or less as an insecticide, principally in combating the San Jose Scale. Like kerosene, it has given very conflicting results and on this account its more general use has been prevented. The fact seems to have been overlooked until somewhat recently that the term "crude petroleum" is not specific but is used to denote a great variety of unrefined oils having a wide difference in their composition. The composition of some of these is such that they are injurious to trees; others are not. This fact doubtless accounts in a large measure for the conflicting results that have been observed in its use as an insecticide.

The recent investigations of Prof. Smith as recorded in Bulletin 146 of the New Jersey Experiment Station throw much light upon this matter and the following comments are taken largely from his experience. The matter is referred to here for the purpose of bringing the attention of those in this state who are interested, to the apparent usefulness of this substance in combating the San Jose scale. It seems probable that the proper grades of crude petroleum are destined to come into more or less general use for this pursose, especially for winter treatment.

The detail of Prof. Smith's experience does not need any extended discussion. Suffice it to say that after extended observation he advises the use of a straight crude petroleum having a specific gravity test on the Beaume oil scale of not less than 43 degrees at a temperature of 60 degrees Fahr. Either the amber colored product or the green may be used. It should have a paraffin base. The value of the asphaltum oils of the West has not been determined. As a rule, crude petroleum with a test below 43 degrees has been injurious. It seems probable that most of the unsatisfactory results have come from not using oils of proper grade.

The crude oil forms a greasy coating over the surface of the tree which remains for several months. So long as this greasy layer exists, the young insects cannot live upon the trees; hence, to a certain extent, the use of crude petroleum is a preventive measure. That is, if an infested tree is sprayed, but the surface of it not completely covered with the oil, the young that may develop from the insects on the unsprayed portions cannot live on those portions having the greasy coating. But on account of the formation of this coating, crude oil cannot be recommended as a summer treatment, in-as-much as the pores of the leaves would become choked thereby. This, of course, would be disastrous to the tree.

*How to Apply It:*—Crude petroleum may be applied in a 20 or 25 per cent mechanical mixture as advised for kerosene, or it may be used undiluted. If the latter, the work must be very carefully done, since only just enough material to thoroughly moisten the surface should be put on. A nozzle making an exceedingly fine spray is essential. The Vermorel with the smallest sized opening answers the requirements well.

If the spraying must be left largely to hands that are more or less careless, Prof. Smith advises the diluted mixture but if the proper attention can be given the matter, he prefers using the undiluted material.

Results recently reported by the West Virginia Experiment Station are in close accord with the observations made by Prof. Smith.

Crude petroleum should not be exposed to the air long before it is used. The lighter oils will evaporate, making the residue too thick to spray readily.

Probably there are several places in the state where crude petroleum of proper grade may be obtained. The essential point seems to be that it possesses a specific gravity of not less that 43 degrees. A green oil of proper density can be had of the Baltimore Division of the Standard Oil Company. Thos. Goodwillie, Merchants National Bank Building, Baltimore, is the General manager of this Division. I am informed that the oil is kept in stock so that orders can be promptly filled. The price quoted me is 12 cents per gallon in barrel lots.

## GENERAL SUMMARY CONCERNING THE USE OF CRUDE PETROLEUM.

1. Crude petroleum seems to be effective in controlling San Jose rcale when properly and intellegently used.

2. Either a green or amber colored oil may be used provided it has a specific gravity of not less than 43 degrees at a temperature of 60 degrees Fahr.

3. It can only be used when the trees are dormant. In this respect crude petroleum and kerosene act directly opposite. (This applies especially to peach trees).

4. It may be used either undiluted or in the 20 or 25 per cent mixture.

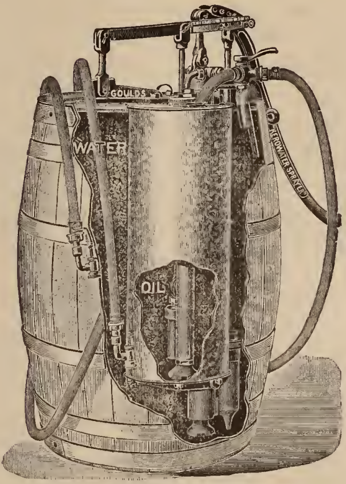


FIG. 15.—A good type of pump for applying a mechanical mixture of kerosene and water.

## SPRAYING APPARATUS.

A word on this subject may not be out of place. There seems to be a good deal of hesitation on the part of many about getting spraying apparatus. It seems to be largely a question of expense but in comparison with other implements found on a well ordered farm, spraying apparatus is not expensive, and for the fruit grower, who would produce the best fruit—especially if he has the San Jose scale—to attempt to get along without a good spray pump is just as illogical as it would be for a farmer, who grows a large acreage of corn, to try to get along without a corn planter, or for one who raises wheat to get along without a binder. The corn planter or the binder cost a good deal more than a spraying outfit. The corn planter is used for a few days in the spring; the binder for a little time in the summer; but there is hardly a week during the whole growing season when a spray pump cannot be profitably used on a farm where a general system of agriculture is practiced.

Any good spray pump can be used in applying undiluted crude petroleum but if diluted, or for kerosene, a pump making a mechanical mixture of oil and water is essential. The "Kerowater" has proven the most satisfactory pump of this type. There are several local agents in this state representing the manufacturers of this pump. The Kerowater can be used

for all kinds of general spraying as well as for applying kerosene. Fig. 15 gives a good idea of the appearance of this pump.

## SPECIFIC STATEMENTS REGARDING TREATMENT FOR THE SAN JOSE SCALE.

In the foregoing discussions mention has been made of the most approved course in combating this pest but it may be convenient if the recommendations are brought together under a common head, even at the risk of making some repetitions.

So far as the use of crude petroleum is concerned, it seems advisable to apply it any time when the trees are dormant. A grade of oil of proper specific gravity should be insisted upon. It may be used either diluted or undiluted.

There seems to be no necessity of using kerosene stronger than a 20 per cent mixture. This should not be used, especially on peach trees when they are perfectly dormant. As soon as the activities of the tree begin in the spring, spraying may be commenced. It will usually be safe to begin from the middle to the latter part of March. In the southern part of the state probably the first of March would be none too early. The most effective work can be done between this time and the putting forth of the leaves, and the energies of those who have this work to do should be concentrated on it during this period. As the spray kills the insects only by coming in contact with them, the applications must be thorough if effective. If more than one application can be made during the time specified, the completeness of the success will be enhanced.

After the spring applications have been made, no further attention need be given until about the middle of June when the insects that have not been killed will begin to produce young. If numerous young are detected on a tree, the tree should be sprayed without delay. A 10 per cent. mixture will kill the young, but as a 20 per cent. mixture will also destroy the adults with which it comes in contact and not seriously endanger the tree (unless already weakened) the use of the stronger mixture is suggested. Several broods of insects are produced during the season. The trees should be frequently examined for them and whenever the little lemon yellow, crawling insects are detected, the trees should be sprayed as already suggested. Anyone with good eyesight can learn, without difficulty, to detect the young if they appear in dangerous numbers, but if the spring treatment has been sufficiently thorough, very little summer spraying will be necessary.

## WHALE-OIL SOAP IN RELATION TO THE SAN JOSE SCALE.

Although the effectiveness of this material is unquestionable and formerly was extensively used in combating the scale, it is seldom recommended now for extensive operations. Other insecticides are cheaper,more convenient and equally effective. But whale-oil-soap still has its place in this warfare. For the small interests of the city or suburban lot or others who have a small number of trees, nothing is more satisfactory. To be effective against mature insects it must be used at the rate of two pounds

of soap to a gallon of water, and applied when the trees are dormant. One pound to five gallons is sufficient to kill the young and this strength can safely be applied at any time. A potash whale-oil soap is more satisfactory than other grades. Good's No. 3* has been extensively used with much success. It points of advantages over other insecticides for small interests may be summarized as follows: It is effective; the aggregate cost for limited operations is not great; it can be obtained in any desired quantity however small; it can be applied with any good spraying apparatus, no pump of special construction being required as in the use of kerosene.

## FUMIGATING WITH HYDROCYANIC ACID GAS.

Bulletin No. 57 containing directions for the use of this gas for fumigating purposes is practically exhausted. Inasmuch as frequent requests are received for information concerning this matter, it seems wise to give herewith a concise outline of the operation with the necessary directions for proceeding with the work.

*The Chemicals:*—1. Cyanide of potassium, 98-99 per cent pure; 2. Sulphuric acid, the best commercial grade; and 3, water. These are all the materials necessary for making the gas. An earthen vessel of some sort is required in which to place these chemicals, while the gas is being generated.

*The Amounts Required:*—For well matured nursery stock .25 (twenty-five hundredths) of a gram of cyanide per cubic foot of space is generally used. That is, for every cubic foot of space in the fumigating box or room, twenty-five hundredths of a gram should be taken.

For June budded peaches and other stock not well ripened and mature, not more than .18 (eighteen hundredths) per cubic foot should be used.

It is generally more convenient to express the amount of cyanide in ounces. This is easily done. The number of grams required is found by multiplying the number of cubic feet in the room or box by .25 (twenty-five hundreths), the amount of cyanide required for one cubic foot. There are 28.35 grams in an ounce; hence the number of grams required for a given space divided by 28.35 gives the equivalent in ounces.

The sulphuric acid necessary for a specified amount of cyanide is one-half more (liquid measure) than the cyanide (by weight); the water should be one-half more than the sulphuric acid. That is, if a fumigating house required 6 ounces (by weight) of cyanide, it would take 9 ounces (liquid measure) of sulphuric acid and 13½ ounces (liquid measure) of water.

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*This can be procured from James Good, 939 N. Front St., Philadelphia.

FIG. 16.—A convenient fumigating house.

*The Fumigating House:*—The most essential thing about the house, room, or box used for this purpose is that it be air tight so that the gas cannot escape. If the enclosure be a house or room, it should be provided with abundant means for ventilation, so that the enclosure can be quickly and thoroughly cleared of the gas when the stock has been exposed to it a sufficiently long time. Fig. 16 illustrates a building intended especially for a fumigating house.

For a small quantity of stock, a box the size of the large ones used by nurserymen for shipping purposes, made perfectly tight by papering and painting will answer the purpose well. An opening that can be tightly closed should be provided along the side, through which the fumigating materials can be inserted. No cover is necessary, but after the trees have been placed in the box, two or three cross pieces can be lightly nailed in to hold them in place; then the box can be turned over and sufficient earth banked around the edges to make it tight.

*How to Proceed.*—The trees should be packed in the room or box rather loosely in order that the gas may have free access to them. In preparing the chemicals, the proper quantity of sulphuric acid should be measured out and placed in some earthern vessel; the required amount of water is then added to the acid. The vessel containing the acid and water should be placed near the center of the enclosure and the requisite quantity of cyanide added. The latter can best be handled by putting it in a small paper bag when it is weighed out, and then dropping the bag with its contents into the liquid. As soon as this is done, the operator must pass out of the room with all possible haste and tightly close the door.

*To breathe any of the gas would be most dangerous to life.* A better arrangement would be to have the bag containing the cyanide suspended above the liquid in such a manner that it can be lowered into it (the liquid) from outside the enclosure.

The stock should be dry when fumigated, at least not drenching wet. If only slightly moist no harm will be done.

*Time Required:*—The trees should be subjected to the gas for thirty minutes. If the fumigation be continued a few minutes longer than this, no harm will result but it is not advisable to extend the time very much. A shorter period than thirty minutes might be insufficient.

After the necessary time has elapsed for the treatment, the room must be thoroughly ventilated for ten minutes or so, to free it of the gas before it is safe for one to enter.

*Treating Trees in the Orchard:*—The foregoing remarks concerning fumigation refer especially to the treatment of nursery stock. This system of combating the San Jose scale and other insect pests is also applicable to orchards, particularly to young trees. The same principles apply as in nursery stock fumigation and in a general way the methods of proceeding are the same in both cases. The only differences of any note are in the enclosure and strength of gas. Twenty hundredths (.20) of a gram of cyanide is advised instead of twenty-five hundredths as for nursery stock. Instead of using a room or box for this purpose, a movable, tent-like affair is generally employed. On account of the cost of tents and the difficulty in handling them, this system of treatment is not advised for large trees, but for trees not much taller than the height of a man, it has many points of merit. For such trees, a box tent is advised. The detail of construction may vary greatly so long as they are made sufficiently tight. A convenient way of making them is to first construct a frame sufficiently large to enclose the trees to be fumigated. This frame is then covered with some material that will render the tent or box tight when earth is banked up around the edges as it sets on the ground. Canvas, treated with one or two coats of boiled linseed oil, may be used for this purpose. Special care must be taken that the joints and seams are thoroughly treated with the oil to make certain that no leakage can take place.

Such a tent can be readily handled by two men and without difficulty placed over trees no larger than the size already referred to. The detail of orchard fumigation need not vary in any essential way from the fumigation of nursery stock. The caution not to fumigate when the trees are drenching wet must be observed.

*CAUTION:—In handling the chemicals used in this work certain cautions need to be observed most rigidly. Cyanide of potash is one of the most deadly poisons known. If an exceedingly small piece of it should be swallowed, it would cause almost instantaneous death. The gas that is generated when the cyanide is placed in the acid is equally as dangerons and every possible precaution should be taken that none of the gas is inhaled. Only a very small quantity of it would cause death, if this caution should be disregarded.*

*The sulphuric acid will quickly destroy clothing if it comes in contact with it; it is also injurious to the flesh. Hence the great necessity of observing the utmost care in handling the chemicals. A thoughtless act, or a moment's carelessness might cause the death of an attendant. No "guess work" is advisable and directions should be most carefully followed. Any "thought-it-didn't-make-any-difference" policy will be sure to be regretted.*

*While the slightest carelessness may make fumigation a most dangerous operation, if due consideration is paid to the matter and sufficient regard is held for pointedly stated facts, no difficulty whatever need be experienced.*

# THE MARYLAND
# AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 74. May, 1901.


## NOTES ON CELERY BLIGHT.


C. O. Townsend.


### INTRODUCTION.

The diseases of celery have been a matter of observation and study at the Maryland Experiment Station and throughout the state during the past three years, and it can be stated with certainty that the greatest hindrance to successful celery culture in Maryland has been and is at present the disease known as Early Blight or Rust. It is equally certain that this disease may be overcome at a trifling expense, by the application of suitable remedies at the proper time. Many failures in celery growing may be traced directly to the blight simply because the plants were not treated or because they were not properly treated with the right fungicide at sufficiently frequent intervals. It is not to be understood, however, that fungicides alone will produce good celery; proper attention must be given to the nature of the soil, to the food and water supply of the plants, to cultivation, and to the other horticultural questions that are of prime importance in celery growing; but given the proper conditions and the proper care, celery of the finest quality may be produced in many parts of Maryland where it is at present a total stranger in both gardens and fields.

### CAUSE AND EFFECT OF CELERY BLIGHT.

Celery blight is due directly to the influence of a delicate thread-like fungus called Cercospora Apii, which grows into the tissues of the celery leaves and causes them to turn brown and to lose their proper functions. This fungus, like all fungi of this class, is reproduced by minute bodies called spores, which are light and easily carried by the wind through long distances and which are able to retain their vitality for an indefinite period. These minute bodies lodge upon the leaves of the celery and under suitable conditions produce the thread-like parts of the fungus that penetrate the surfaces of the leaves and bring about the diseased condition of the plants. The most favorable condition for the development of this fungus is a period of drought accompanied by considerable heat and followed by damp weather. It has been observed repeatedly that when these conditions prevail a serious outbreak of the blight follows, and the destruction is more rapid and more general than when the weather continues moderately dry or moderately moist. When the fungus has penetrated the leaf it increases rapidly, and causes the infested spots to turn brown. The number of these brown or diseased spots upon a leaf varies from one to several, and they increase in size until eventually the whole leaf becomes

discolored and dies. The spots are light at first but are not conspicuous until they turn brown. The outer and older leaves are at first attacked and the disease usually spreads toward the centre of the plant. If the conditions for the development of the fungus are favorable the disease spreads rapidly toward the centre of the plant causing the entire plant to be destroyed, but if the conditions for the development of the fungus are less favorable, the disease works less rapidly and the plant continues to struggle on sometimes through the entire season. It not unfrequently happens that only the outer leaves are seriously diseased, thus leaving the central part nearly free from blight. It is not uncommon to find plants in all stages of injury from blight in the same field, as a vigorous, thrifty, rapidly growing plant will be less liable to severe injury than a weak, stunted plant, since the former is able to outgrow in a measure the effects of the fungus. It is important, therefore, that healthy settings be secured and that they be given every possible advantage for rapid growth and development. It often happens that the fungus attacks the plants while they are still in the seed bed, and for this reason any treatment that the plants are to receive for the prevention of the blight should be begun before the seedlings are transplanted. Here, as in almost all fungous diseases, the highest degree of success depends upon preventing the fungus from attacking the host plants, since it is impossible to destroy the fungus without injuring the plant after the fungus has entered the leaf.

## OBSERVATIONS IN 1898.

The immediate cause that led to the study of celery blight at this time was the apparent inability of the remedies suggested to control this disease, combined with the possibilities of celery growing in Maryland, provided the blight could be overcome with comparative ease and at small expense. During the summer of 1898 a number of celery growers sent to the Experiment Station diseased celery plants or leaves with the request that the cause of the trouble and a proper remedy for the same be furnished. The disease in each case proved to be blight, and with the nature of the fungus in mind, minute directions were given for the preparation and application of suitable fungicides. The directions given were followed by the growers, but in spite of the treatment the plants continued to die, and at the end of the season an almost total failure was reported in nearly all cases. In examining into the cause of the failure of the remedy suggested several questions presented themselves, viz: Was the fungicide used (Bordeaux mixture) the best fungicide for the control of this disease? Are our climatic conditions such that no fungicide will control the disease? Were the applications of the fungicide not sufficiently frequent to keep the fungus in subjection?

The Bordeaux mixture used was made up in the proportion of six pounds of blue stone and six pounds of lime in fifty gallons of water and was prepared in accordance with the usual method of making this mixture. Several applications were made at intervals of from one to two weeks beginning in the latter part of August, too late to have the desired effect, in addition to which the weather was most favorable for the development of the fungus since it was extremely dry during the greater part of August,

followed by frequent showers that kept the soil as well as the atmosphere in a moist condition for several days. In order to answer the foregoing questions and thereby to arrive at proper conclusions in regard to the treatment of celery blight and to convince our growers that celery practically free from disease may be grown in this state, it was decided to carry through a series of tests. Accordingly the following experiments were planned and carried out in 1899 and 1900.

## EXPERIMENTS IN 1899.

While weather conditions are important factors in producing celery blight as well as all other fungous diseases, it is true that no fungus disease will be produced unless the spores of the particular fungus that produce the disease in question are in contact with the plant and capable of germinating. Hence if the spores of the blight-producing fungus can be kept away from the plants or kept from germinating,the blight will not be produced whatever the weather conditions may be. In combating this disease, therefore, it is necessary either to produce those conditions under which the spores of the fungus cannot come into contact with the celery leaves,or to bring about those conditions under which the spores are unable to germinate. In order to determine which method of procedure would be best and for the purpose of finding a satisfactory remedy for celery blight the following experiments were undertaken. A part of one of the beds of late celery on the College grounds was divided into four plats of equal size, each plat containing about one hundred and fifty plants. The several plats were treated as follows: No. 1 was shaded, No. 2 was sprayed with ammoniacal carbonate of copper, No. 3 was sprayed with Bordeaux mixture and No. 4 was left untreated for comparison. We will now consider the methods of treatment and the results in each case.

*Shading.*—In shading plat No. 1 a framework 18 inches high was built over the plat, (one end of which is shown in Fig. 1) and over the frame work was spread a single thickness of muslin. The shading was begun about the middle of July, as soon as the plants were placed in the beds, and was continued throughout the entire hot season of July and August. Early in September the weather turned cooler and the shading was then discontinued, since it has been learned that the celery blight fungus will not thrive in cool weather. Just how far the shading prevents the fungus from growing or renders the celery plants more vigorous and resistent it is difficult to determine. It is entirely possible that the beneficial results of shading were due in a large degree to the fact that the roots of the celery were thereby kept in a cooler condition, thus enabling the celery plants to outgrow in a measure the injurious influence of the fungus.

*Ammoniacal Carbonate of Copper.*—The ammoniacal carbonate of copper used on plat No. 2 was prepared by placing one ounce of copper carbonate in just enough ammonia water to dissolve it and then diluting to nine gallons with ordinary water from the well or hydrant. The amount of ammonia water required to dissolve an ounce of copper carbonate is about one-half pint and this should be diluted from one and one-half to two-quarts of water before the carbonate is placed in it. It should be stated in this connection that the strength of commercial ammonia

FIG. I.—Celery shaded with muslin.

FIG. II.—Celery sprayed with Ammoniacal Carbonate of Copper.

water is so variable that it is impossible to tell just how much will be required to dissolve a given quantity of copper carbonate. But in no case should there be an excess of ammonia since if there is it is liable to burn the foliage. If a large amount of this fungicide is required, either for immediate use or for numerous sprayings at intervals of several days for a period of two or three months, it is much more convenient to prepare a so-called stock solution. This is done by dissolving a comparatively large quantity of copper carbonate in just enough dilute ammonia water to dissolve it. This solution should be so prepared that a known quantity of the copper carbonate is dissolved in a given amount of the liquid, so that in removing a given quantity of the solution we get a definite quantity of copper carbonate, i. e. if ten ounces of copper carbonate were dissolved in ten pints of the liquid, it would be necessary to remove only one pint of the solution and to dilute it to nine gallons in order to get a properly prepared fungicide of the desired strength. The stock solution should be kept in a closely stoppered bottle otherwise it will lose its strength, but in this condition it will keep for several weeks. In addition to the convenience of the stock solution, it is much safer than to prepare the fungicide fresh each time. When the stock solution is once properly made the fungicide may be prepared from it without any danger of injuring the foliage upon which it is used, whereas each time a new solution is made from the original material there is more or less danger of having an excess of ammonia and thereby injuring the foliage when used. In the experiments under consideration, a stock solution of ammoniacal carbonate of copper was prepared and the plants in plat No. 2 were sprayed thoroughly at intervals of from two to four days only,beginning about the middle of July and continuing until the middle of September, when the weather turned cooler. The object in spraying so often was to determine whether or not there was any virtue in this fungicide in preventing celery blight, and not for the purpose of determining how many sprayings would hold this disease in check. In spraying a plant like celery where new leaves are constantly appearing, it is necessary that the spraying should be frequent in order to keep the fungus from getting a foothold on the new growths. At the time the spraying was begun, the outer leaves were already affected by the disease, and as was expected, the fungicide did not restore the diseased leaves, nor did it prevent the disease from progressing in those leaves. On the other hand, however, the central leaves that were healthy or that were developed after the spraying was begun remained almost entirely free from disease and made a good growth as shown in Fig. II. When this plat is compared with plat four as shown in Fig. IV, the benefits of spraying may be easily recognized.

*Bordeaux Mixture.*—Plat No. 3 was sprayed with Bordeaux mixture which was prepared by dissolving one-half pound of blue-stone in two gallons of water, and slaking one-half pound of good stone lime in two gallons of water, then pouring the two solutions together and stirring them thoroughly. This solution should be applied as soon as possible after it is prepared since it loses its virtue after a few hours. In this as in the preceding

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*Note.*—It has been considered advisable to give the methods used in preparing the fungicides, since some growers who are combating this disease are in doubt in regard to the proper methods of preparing and applying the solutions.

FIG. III.—Celery sprayed with Bordeaux mixture.

FIG. IV.—Celery not treated, for comparison.

case it is most convenient to prepare stock solutions provided a large amount of spraying is to be done, or if frequent sprayings of even small areas extending over a period of several weeks are to be carried on. It is most convenient to prepare stock solutions by dissolving a given number of pounds of blue-stone in the same number of gallons of water, slaking a given number of pounds of good stone lime, and then adding the same number of gallons of water as there were pounds of lime; for example, we usually dissolve fifty pounds of blue-stone in fifty gallons of water and slake fifty pounds of lime and dilute to fifty gallons with water. The blue-stone is most quickly dissolved by placing it in a coarse sack and suspending it near the top of a barrel filled with water. In preparing the lime solution, the lumps of lime should be placed in the bottom of the barrel and just enough water added to slake it thoroughly, after which the required amount of water should be added. The stock solution prepared in this manner will keep for several weeks, and from them the Bordeaux mixture may be quickly and easily prepared when wanted. Before using the stock solutions for the purpose of making Bordeaux mixture they should be thoroughly stirred, then one gallon of either solution will contain one pound of the solid from which the solution was prepared. If only one gallon of Bordeaux mixture is desired take one pint of the blue stone solution and dilute to two quarts; one pint of lime solution and dilute to two quarts, then pour the two solutions together and stir vigorously. In the same manner any amount of Bordeaux mixture may be prepared simply by keeping the same proportion of bluestone, lime and water. In the experiment under consideration the sprayings were begun about the middle of July at which time the blight was plainly visible on all the older leaves, and it was not to be expected that the spraying would save them. However, the fact that the disease was so thoroughly established furnished the best possible opportunity for testing the value of Bordeaux mixture in preventing the disease from attacking the leaves that were still healthy. With this object in view and not for the purpose of determining how few sprayings would be necessary, plat No. 3 was sprayed several times each week up to the nineteenth of September, at which time the weather turned cooler and further sprayings were not necessary. As was expected all the leaves that were diseased when the spraying began became gradually worse and finally died. On the other hand, the leaves that were healthy as well as the leaves that came out after the spraying began remained free from disease throughout the season and made a good growth as shown in Fig. III. The plants were not quite as large as in plat 2 where ammoniacal carbonate of copper was used,and it is the general opinion that Bordeaux mixture has a tendency to retard the growth of celery. However, the results were found very satisfactory when plat 3, shown in Fig. III. was compared with the control plat represented in Fig. IV. The cuts of the respective plats were taken from photographs made at the end of the season, Nov. 15th. Bordeaux mixture has a tendency to stick to the celery, and while this quality renders it a good fungicide, it is liable to injure the sale of the plants, if the spraying has to be carried on too near to the harvesting season. This objection may be overcome, if it is desirable to use the Bordeaux mixture, by doing the later sprayings with a colorless fungicide like the ammoniacal carbonate of copper. This makes it necessary to prepare two fungicides

and as already shown ammoniacal carbonate of copper may be used with satisfactory results throughout the season.

*Control.*—The plants in the untreated plat were of the same number and in the same condition as those in the other plats when the experiment was begun. They likewise received the same care and cultivation as the other plats with the exception that no effort was made to control the blight. As the season advanced the disease injured the plants to such an extent that about one-half of them died outright, and of the remaining half the plants were very small owing to the constant attack of the fungus and the consequent loss of leaves. See Fig. IV. and compare with Figs. I. II. and III. The disease advanced from the outer leaves that were first attacked toward the center of the plant so that each plant presented a struggle for existence. If the development of the celery plant was moderately slow, the disease spread to the central leaves and overcame them before they had time to develop, in this way destroying the entire plant. If the celery plant developed more rapidly, it kept ahead of the fungus and lived throughout the season, but in each and every case the plants were seriously injured. Hence the natural vigor and strength of the plant goes far toward resisting the ravages of the blight, but unless some means is used to overcome the fungus, even the strongest plant will be seriously affected and the weaker plants will be completely destroyed.

*Results.*—In summing up the results of the experiments for 1899, the fact stands out very distinctly that celery blight may be kept under complete control by the proper use of the right fungicides.

The best results were obtained with ammoniacal carbonate of copper. This fungicide not only kept all the healthy and new leaves free from the fungus, but the plants grew better than with any other treatment employed. Unfortunately the plats were disturbed just before the celery was dug so that no data of an accurate nature could be obtained except in a general way. The cuts taken from photographs show the general results in a fairly satisfactory manner.

Bordeaux mixture gave results that were in every way satisfactory except that the plants were somewhat retarded in their growth. This is, of course, a serious objection to the use of this fungicide, but it is not probable that the dwarfing of the plants would have been so great if the sprayings had been less frequent, and it is possible that the results in controlling the disease would have been just as satisfactory.

While shading is of considerable advantage to the plants, it does not prevent the attacks and development of the blight fungus. It is possible that a denser shade would have been more satisfactory but it is not probable that even this would have prevented the disease from attacking the plants to some extent. It is also an interesting question in this connection to know what results could be obtained by a combination of shading and spraying. From the fact that the shading is beneficial in keeping the plants and especially the roots cool and also that the fungicides are capable of keeping the plants free from blight, it would seem that a combination of these methods would give good results.

## EXPERIMENTS IN 1900.

In order to reach more definite conclusions in regard to the treatment of celery blight, and for the purpose of obtaining still more exact information in regard to the results of the treatment, it was decided to carry similar experiments through the season of 1900 before reporting fully upon the subject. The plants for these experiments were selected with a view to their uniformity in size and healthfulness. They were planted in beds extending east and west, the rows running crosswise of the beds i. e. north and south, and consisting of ten plants each, set one foot apart. The celery being a late variety again, the plants were transplanted from the seed bed to the garden beds on July 25th, at which time it was noticed that the plants were slightly affected with the blight, proving that it would have been advisable to spray the plants in the seed bed before they were in any degree attacked by the disease. It is not probable that there is any danger of spraying too early and it is very important that the plant be kept free from the fungus, which can be done only by spraying the plants before they are attacked. Experience has shown that the leaves that are attacked cannot be saved and that we can hope to keep in a healthy condition only those leaves that are free from the fungus when the treatment is begun. The plats for these experiments were laid off from one of the beds as follows: No. 1 was shaded, No. 2 untreated for control, No. 3 sprayed with ammoniacal carbonate of copper, No. 4 untreated for control, No. 5 sprayed with Bordeaux mixture. Each plat consisted of ten rows of ten plants each, making one hundred plants in each plat. The soil was uniform in all of the plats and each plat received the same treatment in the way of cultivation and general care as the others, the only difference consisting in the treatment or non-treatment for the blight. No resetting was done in the place of plants that died from any cause; the plats were simply followed throughout the season, and the final results were obtained when the plants were dug.

*Shading.*—As soon as the plants were set in the bed the first ten rows were shaded in a similar manner as in the preceding year, except that a double layer of mosquito netting was used instead of muslin. Out of the one hundred plants in the plat only seventy-five survived throughout the season, and these were small, as will be seen by referring to the table on page 181. It must be remembered however that the plants were more or less seriously affected when they were set, hence just what effect the shading would have had on perfectly healthy plants, it is not possible to say. It is also true that the shading was very light and observation has shown

FIG. V.—An average plant from the shaded plat.

that the deeper the shading the better the results. However, it will be seen by referring to figures VII and VIII that the average plant in the shaded plat was equal to the best in the untreated plats; it is fair, therefore, to conclude that with deep shading the results would be much more satisfactory than no treatment, provided circumstances were such that other treatment than shading was impossible. In these as in the corresponding experiments of the previous year, everything indicates that very satisfactory results could be obtained by a combination of shading and spraying, since the shading not only retards the development of the fun-

gus but also provides more favorable conditions for the growth of the celery plants themselves.

*Ammoniacal Carbonate of Copper.*—Five days after the plants were in the beds they had entirely recovered from the effects of transplanting and the spraying was begun. It was our intention to use the same strength of the fungicide that was used the preceding year, but owing to the fact that the ammonia water was stronger than that previously used and the proper precaution was not taken in preparing the stock solution, an excess of ammonia was present which resulted in considerable damage to the plants at the first spraying. Many of the leaves were injured so that on

FIG. VI.—An average plant from the plat treated with ammoniacal carbonate of copper.

the following day evidences of the foliage having been scalded by an excess of ammonia were plainly visible, and as soon as this was discovered a new stock was properly made and used for all subsequent sprayings. While all leaves that were previously affected or that were injured by the first spraying eventually died, the fungicide kept all new and healthy plants free from the fungus throughout the season. The applications were made once each week until the middle of September, at which time

FIG. VII.—An average plant from the plat treated with Bordeaux mixture

the weather turned cooler and rendered further treatment unnecessary. Of the one hundred plants originally in this plat eighty-six survived throughout the season, but they never recovered from the injury produced by the first spraying, hence the results of this plat do not represent the effects of this fungicide under normal conditions; however, it serves to impress upon us the importance of having our fungicides properly made. It should be stated in this connection that the amount of ammonia water used in making ammoniacal carbonate of copper should be *just sufficient to dissolve the copper carbonate.* Figure 6 represents an average plant from the plat photographed at the digging time, Nov. 19, and the table on page 181 compares this plat with the other plats under consideration. If properly prepared, this fungicide is more satisfactory than Bordeaux mixture as shown by the previous year's experiments as well as by the experiences of others. The advantages of this fungicide over Bordeaux mixture have already been stated.

*Bordeaux Mixture.*—The first application of Bordeaux mixture was made on July 30th at which time the plants in this plat had entirely recovered from the effects of transplanting. The Bordeaux mixture used was prepared in the same manner as in the experiments of the preceding year, and the applications were made weekly until the cool weather appeared which was about the middle of September. The leaves that were diseased when the plants were transplanted from the seed bed died, but all other leaves remained healthy and made a good growth, as shown from Fig. 5 and also from the table on page 181. It should be stated that figures from V to IX inclusive were made from photographs taken at the time the celery was dug, and show the relative size of the plants from the several plats. Ninety-six of the one hundred plants in this plat survived the entire season and all were of marketable value. The four plants that died, dried up soon after they were set out but did not appear to be destroyed by the blight. In a commercial bed their places could easily have been filled by new plants, which, if properly sprayed, would have made a solid bed of marketable plants. One of the average plants is shown in Fig. VII.

*Control Plats.*—The plants in the two control plats averaged seventy-three plants in each plat, i. e. out of the original one-hundred plants, twenty seven died and the remaining seventy-three were small and many of them were absolutely worthless. Fig. VIII shows one of the best of the control plants and figure IX shows one of the poorest. It is apparent that all these control plants were more or less seriously affected by the blight. In some instances the plants developed more rapidly than the blight and therefore made some growth in spite of the disease. In other cases the fungus developed most rapidly so that each new leaf as it appeared was soon affected, with the result that the life of the entire plant was eventually destroyed. Between these two extremes were plants in all stages of disease, but very few of them had any market value.

*Results.*—The results of the season's experiments may be best expressed in the following table which was prepared by actual count and weight at the end of the season, Nov. 19th, when the plants were dug. Treatment was begun July 30th and continued until cool weather appeared about September 15th.

FIG. VIII.—One of the best plants from a control plat.

TABLE.

| No. of plat. | Kind and nature of treatment. | Original number of plants in plats. | No. of plants that survived throughout the season. | Total wgt. of plants at end of season. | Average wgt. of individual plant. |
|---|---|---|---|---|---|
| No. 1 | Shaded from July 30 to Sept. 15. | 100 | 75 | 2 lbs. 2 ozs. | 4 and $\frac{2}{5}$ ozs. |
| No. 2 | Control. | 100 | 72 | 13 lbs. 8 ozs. | 3 ozs. |
| No 3 | Sprayed once a week with ammon. carb. copper. | 100 | 86 | 28 lbs. 4 ozs. | 5 and $\frac{1}{4}$ ozs. |
| No. 4 | Control. | 100 | 74 | 17 lbs. 8 ozs. | 4 and $\frac{7}{8}$ ozs. |
| No. 5 | Sprayed once a week with Bordeaux mixture. | 100 | 96 | 46 lbs. 8 ozs. | 7 and $\frac{3}{4}$ ozs. |

FIG. IX.—One of the poorest plants from a control plat.

It is apparent from those experiments that celery blight may be readily controlled by treatment. Spraying with either Bordeaux mixture or ammoniacal carbonate of copper will entirely prevent the attacks of the celery blight fungus. It appears from the above table that Bordeaux mixture is more satisfactory than ammoniacal carbonate of copper, but previous experience as well as the experience of others shows that ammoniacal carbonate of copper (when properly made) is entirely satisfactory in keeping the plants free from blight. The treatment should be begun before the plants are attacked by the blight, hence the first spraying should be done while the plants are in the seed bed. In the above table the number as well as the weight of plants in the control plats does not represent fully their value as compared with the plants in the treated plats, since practically all the plants in the control plats were worthless while those in the treated plats were practically all of more or less value; hence the table should from a commercial standpoint show zero for the control plats as compared with the values given for the treated plats.

## EXPERIENCES OF OTHERS.

One grower in 1898 who was unable to control the blight because the treatment was not begun early enough, estimated his loss at one thousand dollars. This treatment as outlined in the preceding pages if taken in time would have saved that amount to one grower in one season and it is safe to say that many others sustain losses of larger or smaller amounts each year, all of which might be saved to the growers and to Maryland, if the plants were given the proper treatment throughout the season. Some growers from central and southern Maryland who have tried spraying celery for the past two seasons write that they have been very successful in controlling the disease by the proper application of fungicides. Some have used ammoniacal carbonate of copper with entire satisfaction while others have used Bordeaux mixture with equal success. The following letter from Mr. Henry Holzapfel of Hagerstown shows how easily and completely the disease may be controlled in Western Maryland.

Prof. C. O. Townsend, College Park, Md.

My Dear Sir:—In reply to your favor I would say that in our altitude celery blight is not as difficult to control as it appears to be in our lower counties. I use but one spray, namely:—the ammoniacal carbonate of copper solution. The proportions I use are 5 ounces carbonate of copper, 2 quarts strong ammonia, 40 gallons water. We begin to spray in the seed bed when plants are yet small, and after transplanting to the field spray at least once every two weeks, until cool weather renders it unnecessary. We have no insect enemies that do any noticeable harm. Bordeaux mixture does not seem very effective in controlling the blight and is objectionable on account of the way it adheres to the plants, apparently stunting their growth. Very Respectfully,

(signed) Henry Holzapfel, Jr., Hagerstown, Md.

Although the blight is more difficult to control in our lower counties owing to the more favorable conditions for the development of the fungus, it may be controlled with equal success as in other sections by applying the fungicide more frequently.

## SUMMARY.

Celery blight or rust is the only pest that is to be feared at present by growers, but this disease alone may cause complete destruction of the celery crop if no measures are taken to control it.

Celery blight may be kept under complete control by spraying either with ammoniacal carbonate of copper or with Bordeaux mixture.

The spraying should be begun while the plants are still in the seed bed, and should be continued at intervals of from one to two weeks after the plants are transplanted until the cool weather prevents the further development of the fungus. Each application of the fungicide should be thorough.

Shading will retard the progress of the disease but will not entirely prevent it from doing more or less damage.

# THE MARYLAND
# AGRICULTURAL EXPERIMENT STATION.

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## THE EFFECT OF HYDROCYANIC-ACID GAS UPON GRAINS AND OTHER SEEDS.

By C. O. Townsend.

### INTRODUCTION.

1. The object of the experiments described in this Bulletin has been to determine the effect of Hydrocyanic-acid gas upon the germination of seeds and also to see if the poisonous gas renders the fumigated grains unfit for food. The necessity for this work arose from the rapidly increasing use of this gas in the destruction of insect pests infesting stored grains and other seeds. Since these experiments were begun, a number of the largest flour mills in this country and Canada as well as a large number of barns and granaries filled with grain have been fumigated for the destruction of insects without removing the thousands of bushels of grain stored in the buildings. In as much as the grain thus fumigated may be used either for seed or for food it is important to know whether or not the germinating quality of the grain has been injured and whether grain thus treated would be injurious when used as food. Before taking up the effect of the gas upon grains and other seeds, it will be best to consider the methods actually employed in fumigating mills etc. containing the stored grain.*

*How the Gas is Made.*—Hydrocyanic-acid gas is made by a combination of potassium cyanide, sulfuric acid and water. The chemicals and liquids are weighed and measured accurately, after the cubic capacity of the enclosure has been determined. This process will admit of no guess work and must be done specifically according to directions. The acid is first placed in a crock or any earthenware vessel; then the water is poured in, and as considerable heat is evolved steam will rise from the vessel. At this time the cyanide, which is held in a small paper bag, is dropped into the liquid, bag and all. The acid soon eats through the paper and we get a bubbling and steaming, similar to what would be produced if a piece of red-hot iron was dropped into a basin of cold water. This lasts for a few

*Note.—The accompanying description of methods used in fumigating stored grain was written by Prof. W. G. Johnson and published in the "American Miller," Nov. 1, 1899, under the title "Hydrocyanic Acid Gas as a Remedy for Insects in Mills and other Enclosures" These directions are here reproduced with the consent of the writer

minutes only, or until the acid acts upon all the cyanide. A cloud of whitish steam will rise, and is almost instantly disseminated through the room. The odor of the gas is decidedly that of peach pits, and easily detected. IT IS THE MOST DEADLY GAS KNOWN TO CHEMICAL SCIENCE, AND MEANS SURE DEATH TO ANY ANIMAL INHALING IT. For this reason, it must be handled cautiously. If a human being should breathe his lungs full of it, the chances are he would not know when he took a second breath, if he got it at all. When handled with due care there is no danger whatever.

*The Chemicals.*—The potassium cyanide must be practically chemically pure, guaranteed 98-99 per cent. It should be broken in lumps about the size of shell bark hickory nuts to get the best results. It can be procured in small lumps when requested and may be bought for about thirty cents per pound in bulk, that is, the original 100-pound package. In smaller quantities the price varies from 32½ to 36 cents per pound.

Only the best grade of sulfuric acid should be used; specific gravity, 1.83. A cheap grade used in the manufacture of commercial fertilizers, known as chamber acid, will not do. I purchase the best grade in carboy lots at 1½ cents per pound.

Water from any well or cistern will answer; the only requisite being that it shall be clean

*Estimating Amounts.*—If we were going to fumigate a room we would first obtain the exact cubic contents. For example, say we had a room 20x30x10 feet Multiplying these together we get 6,000 cubic feet. We now multiply this by .25 (twenty-five hundredths), as we use .25 of a gram of cyanide for every cubic foot of space enclosed. Thus, 6,000 x .25=1.500 grams. We want to reduce this to ounces, so we divide 1,500 by 28.35, as there are 28.35 grams in an ounce. Thus, 1,500÷28.35=53 ounces. This (53 ounces) is the amount of cyanide needed. It is now easy to find the amount of acid and water, for we use a half more acid (liquid measure) than cyanide, and a half more water than acid. Thus, 53÷2=26½, which added to 53 gives 79½ ounces acid or practically 5 pounds. Again 79½, or practically 80÷2=40, which added to 80=120 ounces water.

The room 20x30x10 thus will require 53 ounces (by weight) of cyanide, 80 ounces (liquid measure) of acid, and 120 ounces (liquid measure) of water; the total cost of the chemicals being about $1.26.

*Application.*—The application is a very important part. It is not desirable to use over one pound of cyanide in a bag. I would, therefore, divide the total amount, 53 ounces, into three lots, two of 18 ounces each, and one 17 ounces, placing it in small paper bags. We now need three pickle jars, or crocks of 1½ or 2 gallons capacity each, which should be distributed evenly about the room. We now prepare our acid and water. It will be remembered that we have two 18 ounce packages and one 17 ounce. In each jar for the former we place 27 ounces of acid and 40 ounces of water, in the later 25½ ounces of acid and 38 ounces of water.

Each bag of cyanide should now be suspended by means of a string over the jar containing the liquid. The strings should be so arranged that they can be passed to the outer door, from which point all three bags

are lowered at the same time into the liquids. The door is then closed and no one allowed to enter.

*Time Required.*—It would be preferable in most cases to fumigate in the evening and leave the mill over night. I would not leave the gas less than an hour in a room, and longer if possible. Over night or all day would be preferable.

*Caution.*—In preparing to fumigate it must be borne in mind that this gas is very penetrating and diffusive, and therefore, every crack and crevice leading outside should be stopped. The windows and doors should be arranged so that they may be opened from the outside, and after fumigation thrown open, so as to ventilate the room from 25 to 30 minutes before entering.

There is no danger of fire or explosion from this gas. It must not be inhaled by the individual. The potassium cyanide, which is a solid, resembling lump or white sugar, is quite as dangerous as the gas. If a piece as large as a pin's head should get into a man's stomach it would kill him. Do not handle it with your fingers. In fact, I would not advise any miller to use it in bulk. He had better have his druggist do his weighing, after he has estimated his amounts and the number and size of the packages required. When in the bags tied up there is not so much danger. The cyanide, if kept any length of time, must be secured in a perfectly air-tight can. Otherwise it will liquify in a short time if exposed to the air. Label it "poison" and keep it out of the reach of children and other persons. After fumigation is over the contents of the jars should be buried. At first the residue is a greenish white liquid, but, when cold, will solidify like thick paste or even crystallize. Wash the crocks with water afterward.

Do not try to use tin jars for the acid and water. as the acid will "eat them up." See that nobody goes into the mill during fumigation, and to make sure, detail a man to remain on guard all the time.

If you have a worthless cat or dog, put it in the room before fumigation and note result.

If a whole building, containing several stories, is to be fumigated, begin at the top and work downward, having everything in readiness.

I think I have cited all the cautions necessary, and if they are duly heeded, there will be no accidents. In my first experiments in mills I began by using .10 and .12 of a gram per cubic foot. By further experiment we have found that from .20 to .25 of a gram is preferable. It generates a greater volume of gas and remains in the building longer."

The use of hydrocyanic-acid gas for fumigating purposes is of comparatively recent origin, having been introduced by the U. S. Dept. of Agr. Div. of Entomology in 1886 for the fumigation of orange trees. Since its introduction it has come into use for the fumigation, not only of orchard trees but also of nursery stock, green houses, cold frames and finally for the destruction of insect pests in buildings, especially where grain is stored. The following experiments deal only with the effect of the gas upon grains and other seeds.

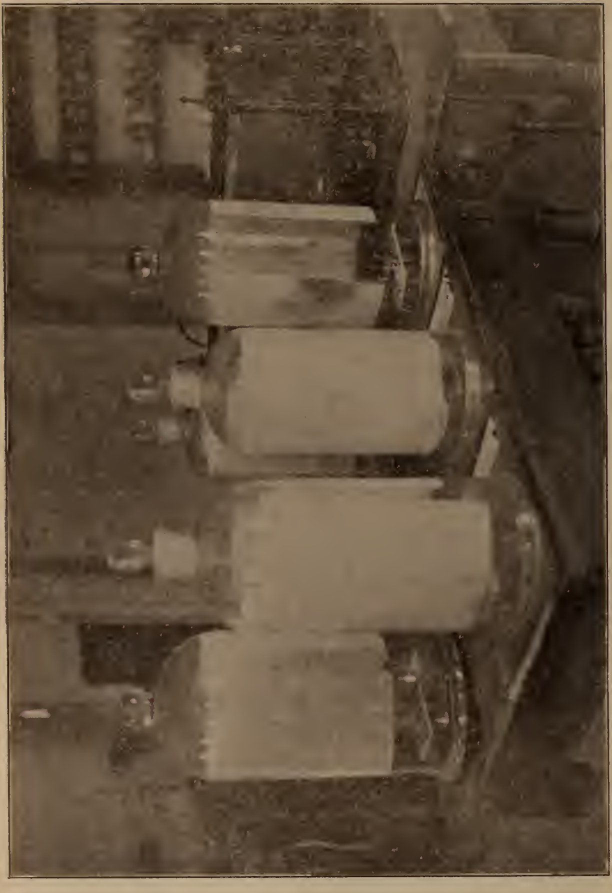

FIG. I.—Bell jars in which the effect of hydrocyanic acid gas upon the germination of seeds is being determined.

## METHODS.

In general, the methods employed in these experiments consisted simply in placing the seeds to be tested in air-tight chambers and then generating the desired amount of hydrocyanic-acid gas. In the first experiments, the chambers consisted of air-tight boxes of several cubic feet capacity, used primarily for the fumigation of nursery stock These boxes were open on one side, the open side being placed next to the ground, which was first made perfectly smooth and level. In experimenting with these boxes, they were raised slightly on one edge, the seeds to be fumigated were placed under them, and at the moment the hydrocyanic-acid gas was generated the boxes were lowered and sand quickly pressed around the edge next to the ground, making it practically gas tight. In these as in the subsequent experiments the gas was generated as in actual fumigation by placing cyanide of potassium in dilute sulfuric acid, the result of the chemical action being the evolution of hydrocyanic acid gas. In the later experiments, glass bell-jars, having a capacity of one-third of a cubic foot each were used. (See Fig. 1.) The jars were so arranged that the desired amount of gas could be generated and kept in the jars for any required length of time after the seeds were placed in them.

If the seeds were to be fumigated while dry, no moisture was added except what was used to dilute the acid and this consisted of only a few drops. On the other hand, if damp seeds were to be treated with hydrocyanic-acid gas, the seeds were soaked for the desired length of time in water, and then placed on moist filter paper under the bell jar, while the bell jar itself was lined with damp filter paper, thus providing for the seeds a moist atmosphere favorable for their germination. All the jars, whether damp or dry, were kept at ordinary temperature. The materials used in these experiments consisted for the most part of corn, wheat, beans and clover seed. Occasionally other seeds were used in addition to those mentioned, but these four were carried through all the experiments and may be considered as fairly representing the common grains and other seeds. Under certain conditions some of the seeds used seemed to be more sensitive to the treatment to which they were subjected than the others, but in general the behavior of the seeds under the conditions used was similar for all seeds under identical conditions, the difference being simply a matter of degree. In other words, if the effect of the treatment was to increase the rate of germination, all the seeds germinated more quickly than under natural conditions, whereas if the effect of the treatment was to retard germination, then all germinated less readily than under natural conditions, although all seeds of the same kind did not germinate at the same time.

In these experiments the strength of the gas varied from .003 of a gram per cubic foot to 1.45 grams per cubic foot. While in the first experiments the object was simply to determine whether or not the ordinary strength of the gas used in fumigation would be harmful to the grains or other seeds, in the later experiments an effort was made to determine the maximum and minimum strength of gas that the seeds could resist under the several conditions used. It should be noted that time is an important factor in these experiments. Nursery stock may be fumigated in thirty minutes so that all

insect life will be destroyed; but in fumigating buildings in which large bulks of grain are stored, time must be allowed for the gas to penetrate the mass of grain and thus reach the insects that may be scattered through it. While time is being given for the gas to penetrate the bulk of grain, the grain on the surface of the bulk is exposed to the influence of the gas from the time it is generated. Hence an effort was made to determine the shortest and longest time required for the grains to respond to the influence of the various strengths of gas under the several conditions employed and with this point in view the exposures varied from one hour to one year.

### EXPERIMENTS WITH DRY SEEDS.

*Trial Experiments.*—In the first experiments dry seeds were placed in shallow dishes and exposed for one hour to charges of gas varying in strength from .25 of a gram of potassium cyanide to 1.45 grams of potassium cyanide per cubic foot. Only a thin layer of seeds was placed in each dish so that the gas came directly into contact with each seed. At the end of one hour the seeds were taken from the fumigating chamber and placed in water for twenty-four hours. At the end of this time the seeds were spread upon moist filter paper in damp chambers and kept at ordinary room temperature. In this as in all the other tests control experiments were used in which the seeds were treated in precisely the same manner and kept under exactly the same conditions as those in the experiments, except that they were not subjected to the influence of the gas.

In all cases it was found that the seeds that had been subjected to the gas for one hour generated just as readily as if they had not been in the gas at all. Hence it may be concluded that perfectly dry seeds may be subjected for a short time to the influence of gas six times as strong as that ordinarily used in fumigating grains without any appreciable injury to the germinating quality of the seed. Hence there is no danger of using a charge of gas that is large enough to injure the germination of the grain.

TABLE I.

*Dry seeds subjected to the influence of hydrocyanic acid gas for one hour, soaked and placed under conditions favorable for germination.*

| Strength of gas used | Time seeds were exposed to gas. | Time seeds were soaked. | Time required for germination | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|---|
| 0.00 | 1 hour | 24 hours. | 24 hours. | 100 | Normal. |
| .25 | " | " | " | 100 | " |
| .45 | " | " | " | 100 | " |
| .60 | " | " | " | 100 | " |
| .75 | " | " | " | 100 | " |
| 1.00 | " | " | " | 100 | " |
| 1.25 | " | " | " | 100 | " |
| 1.45 | " | " | " | 100 | " |

*Subsequent Experiments.*—In the trial experiments it was seen that the seeds were under the influence of hydrocyanic-acid gas for one hour only. In order to determine the influence of this gas upon seeds exposed for a long time subsequent experiments with dry seeds were undertaken. The seeds were placed in shallow dishes which were covered by the bell-jars, made air-tight and the gas generated in the manner described.

TABLE II.

*Dry seeds treated with hydrocyanic acid gas for long periods of time.*

| Amount of potassium cyanide per cubic foot. | Time seeds were in gas. | Time seeds were soaked. | Time required for germination | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|---|
| 0.000 | 0 | 24 hours | 24 hours | 100 | normal |
| 0.333 | 15 days. | " | 12 hours | 100 | accelerated |
| 1.000 | 15 " | " | 7 hours | 100 | accelerated |
| 0.333 | 60 " | " | 9 hours | 100 | accelerated |
| 1.000 | 60 " | " | 14 hours | 100 | retarded $\frac{1}{3}$ |
| 0.333 | 153 " | " | 30 hours | 75 | retarded $\frac{1}{2}$ |
| 1.000 | 153 " | " | 36 hours | 60 | slight |
| 0.333 | 240 " | " | 76 hours | 50 | very slight |
| 1.000 | 240 " | " | 96 hours | 10 | none |
| 0.333 | 365 " | " | 240 hours | 20 | none |
| 1.000 | 365 " | " | no germination | 0 | ——— |

*a* *b* *c*

FIG. II.—*a*, control; *b*, from seeds that were eight months in gas from 0.333gm KCN per cubic foot; *c*, seeds that were eight months in gas from 1gm KCN per cubic foot.

From the foregoing table it will be seen that the seeds were constantly under the influence of the gas for from fifteen days to one year. The strength of the gas was constant in each jar i. e. it did not vary except possibly by the absorption of a small quantity of the gas into the seeds and into the small quantity of dilute acid used in generating the gas. It is to be noted that the seeds germinated more readily after they had been exposed to the gas for a few days.

At the expiration of sixty days, however, the increased rate of germination had passed its maximum and shortly after began to be retarded, until at the end of two hundred and forty days germination practically ceased for those seeds that were exposed to the gas from one gram of potassium cyanide per cubic foot. The seeds that were in the weaker charge of gas continued to germinate about four months longer, but that was evidently the limit as only a few of the seeds germinated and only very feebly at the expiration of that time. (Fig. II). Not only was the germination hastened but the subsequent growth of the seedlings was likewise accelerated for a limited time. Although the subsequent growth of seedlings was in some instances very marked being almost double that of the normal, this acceleration was of short duration rarely lasting more than one week and then gradually resuming the normal rate of growth. Hence the acceleration is probably not of sufficient duration to be of any commercial value. It appears from these experiments that dry seeds may be treated with hydrocyanic-acid gas continuously for several weeks without reducing the percentage of gemination or interfering seriously with the subsequent growth of the seedlings. It is clear however that the gas has a marked influence upon dry seeds. The extent of the influence depends upon the amount of gas per cubic foot and upon the time the seeds

a b c

FIG III.—*a*. control: *b*. seeds that were one year in gas from 0.333gm KCN per cubic foot; *c*, seeds that were one year in gas from 1gm KCN per cubic foot.

are subjected to its influence. After sixty days the percentage of germination was gradually reduced and the subsequent growth of seedlings was likewise retarded. The greater reduction in the percentage of germination as well as in retardation of growth depended upon the length of time of exposure to the gas and upon the amount of gas present. At the end of 8 months the seeds in the gas from 1 gram of potassium cyanide

FIG. IV.—Corn and wheat seedlings. The larger one in each case is normal, while the smaller ones were from seeds treated eight months with gas from 0.333gm KCN per cubic foot.

per cubic foot had practically lost their ability to germinate, since only one in ten was capable of even slight germination, and those were too feeble for subsequent growth. If the gas was generated from only one-third of a gram of potassium cyanide per cubic foot, the seeds retained their ability to germinate four months longer or one year from the beginning of the experiment.

## MOIST SEEDS.

Since it may sometimes be necessary to fumigate grain or other seeds while in a moist condition, experiments were undertaken for the purpose of determining what effect hydrocyanic-acid gas would have upon seeds that had been soaked for a longer or shorter time in water. After soaking the seeds the following conditions were observed viz: the damp seeds were left to germinate in the gas which was of different strengths in different jars; the damp seeds were placed for a time in the gas of different strengths and then removed to an atmosphere free from gas.

## DAMP SEEDS ALLOWED TO REMAIN IN THE HYDROCYANIC-ACID GAS.

By referring to tables III, IV, and V it will be seen that the seeds were soaked for different lengths of time, and that they were subjected to atmospheres of gas of different strengths.

### TABLE III.

*Germination of damp seeds and subsequent growth of resulting seedlings in hydrocyanic-acid gas.*

| Amount of potassium cyanide per cubic foot. | Time seeds were soaked. | Time required for germination. | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|
| .000 | 24 hours | 24 hours | 100 | normal |
| .003 | " | 168 " | 90 | very slow |
| .010 | " | no germ | 0 | ——— |
| .050 | " | no germ | 0 | ——— |

It will be observed in table III that the amount of potassium cyanide used varied from .003 to .050 of a gramper cubic foot, but that no germination took place if more than .003 of a gram was used and indeed in this strength of gas germination was delayed for six days. Other quantities of potassium cyanide between .003 and .010 of a gram were used, but the seeds seemed to be unable to germinate in any charge stronger than .003 of a gram per cubic foot. The subsequent growth of the seedlings in this very small amount of hydrocyanic-acid gas was very slight and did not exceed two inches in ten days, in some instances the growth being only a fraction of an inch in that time.

a b c

FIG. V.—a, control; b, seeds were in gas from .003gm KCN per cubic foot for 168 hours; c, seeds were in gas from .010gm KCN per cubic foot 168 days—Photographed at end of 18 days .See table VI.

TABLE IV.

*Same condition as in table III except that the seeds were soaked for a shorter time before placing in the gas.*

| Amount of potassium cyanide per cubic foot. | Time seeds were scaked. | Time required for germination. | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|
| .000 | 12 hours | 24 hours | 100 | normal |
| .003 | " | 36 " | 80 | slight |
| .010 | " | 36 " | 40 | very slight |
| .050 | " | 40 " | 20 | none |
| .060 | " | no germination | 0 | ——— |

In the experiments recorded in table IV. the seeds were soaked only twelve hours, but the control seeds germinated in practically the same time as in the preceding case where the seeds were soaked for twenty four hours. It is also important to note that the small charge of only .003 of a gram of potassium cyanide retarded the germination but a few hours as compared with the retardation produced by the same charge of gas when the seeds were soaked for twenty four hours. It is likewise a note worthy fact that when the seeds were soaked but twelve hours they were much more resistent to the influence of hydrocyanic-acid gas, as evidenced by the fact that at least a few of the seeds were able to germinate in as much as .050 of a gram of potassium cyanide per cubic foot. The sub-

sequent behavior of the seedlings was the same as in the preceding case i. e. there was little or no growth after the plant escaped from the seed coats. In general it was found that the shorter time the seeds were soaked the more resistant they were to the influence of the gas.

TABLE V.

*Same condition as in Table III. except that the seeds were soaked for a longer time before placing them in the gas.*

| Amount of potassium cyanide per cubic foot. | Time seeds were soaked. | Time required for germination. | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|
| .000 | 36 hours | 20 hours | 100 | normal |
| .003 | " | 48 hours | 60 | slight |
| .010 | " | no germination. | 0 | ——— |
| .050 | " | " " | 0 | ——— |

In these experiments it will be seen that the extra amount of soaking caused the seeds to germinate more readily than they would have done had they been soaked but twenty four hours, both in the case of the control experiments and in the experiments in which but .003 of a gram of potassium cyanide was used. However, the seeds did not germinate as readily as they did when soaked but twelve hours nor was the percentage of germination so high as in either of the preceding cases. It is probable that the germination took place more quickly than in the experiments recorded in Table III., because the seeds were more advanced before they were removed from the water and placed in the gas. In all cases the seedlings were extremely sensitive and made but very slight growth after breaking through the seed coats. Leaving out of account the advance that the seeds made toward germination while they were in the water and before placing them in the gas, it appears that their sensitiveness increases with the length of time that they are allowed to soak.

When it was observed that the seeds that had been soaked and then placed in hydrocyanic-acid gas germinated more slowly than under normal conditions, it was apparent that the seeds were being held in a dormant state for a longer or shorter time depending upon the length of time the seeds were soaked, upon the strength of gas used, and upon the length of time that the seeds were allowed to remain in the gas. In order to get more definite information in regard to this point, experiments, the results of which are recorded in Tables VI. and VII., were undertaken.

TABLE VI.

*Germination of seeds and subsequent growth of seedlings after soaking seeds in water and then placing for a definite time in hydrocyanic-acid gas and then removing to a gas-free atmosphere.*

| Amount of Potassium cyanide per cubic foot. | Time seeds were soaked. | Time seeds were in gas. | Time of germination after removing from gas. | Percentage of germination. | Subsequent growth of seedlings. |
|---|---|---|---|---|---|
| .000 | 24 hours | 0 | 24 hours | 100 | normal |
| .003 | " | 168 hours | already germinated | 90 | slow |
| .010 | " | " | 168 hours | 50 | very slow |
| .050 | " | " | 336 hours | 20 | barely started |
| .060 | " | " | no germination | 0 | ——— |

As shown in Table III seeds that had been soaked for twenty four hours and then left for seven days or 168 hours in an atmosphere containing gas from .003 of a gram of potassium cyanide per cubic foot were able at the end of that time to germinate without removing the seeds from the gas, while seeds subjected to a stronger charge of gas were unable to germinate in the gas. Hence the experiments as recorded in Table VI were undertaken. In these experiments the seeds were treated as in the experiments recorded in Table III, except that at the end of seven days the seeds exposed to the gas from .010 of a gram or more of potassium cyanide per cubic foot were removed from the gas and placed in a gas-free atmosphere. At the end of seven days after placing the seeds in ordinary atmosphere 50% of those seeds that had beed exposed to the gas from .010 of a gram of potassium cyanide germinated. In other words the seeds that germinated had been held in a dormant condition for six days in the gas and for seven days after removing from the gas, a total of thirteen days. Likewise seeds that had been in the gas from .050 of a gram of potassium cyanide per cubic foot were held in a dormant condition for twenty days. In the preceding case only five seeds out of every ten germinated while in the latter instance only two out of the ten germinated. Hence it should be noted that much depends upon the natural vitality of the seeds, not only in these experiments but in all cases where seeds are subjected to similar treatment. If the seeds were subjected for seven days to a charge of gas greater than that produced from .050 of a gram of potassium cyanide per cubic foot they were unable to germinate in a single instance. In those places where germination did take place, the subsequent growth of the seedlings was always slow and feeble. It is true that some of the seedlings in these as well as in other experiments where the subsequent growth was slow were able to overcome the influence of the gas after a longer or shorter time and to grow at the normal rate.

Since the seeds subjected to the gas from more than .050 of a gram of potassium cyanide per cubic foot were unable to germinate, it was decided to test the effect of a comparatively strong charge of the gas for a short time. The results of these experiments are recorded in Table VII.

TABLE VII.

*Same condition as in Table VI, except that a stronger charge of hydrocyanic-acid gas was used for a short time.*

| Amount of potassium cyanide per cubic ft. | Time seeds were soaked. | Time seeds were in the gas. | Time required for germination after removal from gas | Percentage of germ. | Subsequent growth of seedlings. |
|---|---|---|---|---|---|
| .000 | 24 hours | 0 | 24 hours | 100 | normal |
| .250 | " | 3 hours | 74 hours | 50 | " |
| .250 | " | 6 " | no germination | 0 | ——— |
| .250 | " | 12 " | " " | " | ——— |

## CONCLUSIONS.

Seeds whether in the dry or moist condition are capable of absorbing hydrocyanic-acid gas from the surrounding atmosphere whether the amount of gas in the atmosphere is large or small per cubic foot. The gas thus absorbed has a marked influence upon the germination of the seeds and upon the subsequent growth of the seedlings. In these experiments it was found that some of the seeds were able to resist for more than three hours the influence of the gas from .25 grams of potassium cyanide per cubic foot, although after three hours, 50% of the seeds were unable to germinate and the other half were held in check for forty-eight hours beyond the usual time of germination. However, the seeds that did germinate produced seedlings that grew at the normal rate. If the grains or seeds are dry, the influence of the gas is far less marked than if they are moist, and the drier they are, the less they are influenced by the gas. It would seem therefore that the gas exerts its influence through the medium of the moisture contained in the seeds and in the seedlings. Even in older plants it is the more succulent parts that are most readily affected by the gas. The seed coats serve more or less as a protection for the inner seed parts, and as soon as the seedlings escape from the seed coats they are more seriously affected by the gas and if the charge is sufficiently strong, the seedlings refuse to grow almost as soon as they leave the seed coats. Dry seeds are sufficiently resistant to the influence of hydrocyanic-acid gas to be treated for several weeks with an atmosphere saturated with the gas without destroying their vitality. It would be impossible however to preserve even dry seeds indefinitely in any strength of the gas, since it eventually penetrates the dry seeds and impairs and finally destroys the vitality of the seeds. If the seeds are damp they are much more susceptible to the influence of the gas, and should not remain more than two or three hours in gas of sufficient strength to destroy animal life.

## EFFECT OF HYDROCYANIC-ACID GAS ON SEEDS FOR FOOD. DRY SEEDS.

Only a few experiments have been performed along this line but probably a sufficient number to determine the point in question, viz., whether dry seeds treated with hydrocyanic-acid gas retain enough of the gas to make them injurious to animal life. Grain was subjected to gas of different strengths and for longer or shorter periods of time, varying from one to sixty days. Grains thus treated were from time to time fed to mice that had been caught without injury and placed in glass cages so that they could be observed constantly. The cages were provided with

an abundant supply of air and water and kept at ordinary normal temperature of the laboratory where the mice had been living previous to the beginning of the experiment. Occasionally the mice began eating the grains as soon as they were placed within reach, but as a rule, several minutes to several hours elapsed between the time the grains were taken from the hydrocyanic-acid gas and the time they were eaten by the mice, thus giving time for any gas that remained in contact with the seed or that had penetrated the seed coat to escape into the atmosphere.

In one instance, for example, a mouse was fed one dozen kernels of corn and three dozen grains of wheat that had been for four and one fourth days in an atmosphere containing gas from one gram of potassium cyanide per cubic foot. The mouse began eating the grain at once and at the end of twenty four hours had eaten the whole of five grains of corn and had eaten the chit out of five other grains. It had also eaten fourteen grains of wheat and had eaten the chit of eleven others without injury. Several similar experiments were carried through with like results. Hence it seems safe to conclude that dry grains treated for several days with hydrocyanic-acid gas of sufficient strength to destroy insect pests that may be in the grain will in no way poison the grain, and it may therefore be used for food without injury.

*Damp Seeds.*—The damp seeds were soaked for twenty four hours and then treated with gas in the same manner as in the preceding experiments and were kept in the gas for different periods of time varying from several hours to several days in the different experiments. Here as in the germination experiments we find that moisture has a decided influence upon the ability of the grains to absorb gas, i. e. after soaking some corn and wheat for twenty four hours in water and then leaving for forty eight hours in the gas obtained from one gram of potassium cyanide per cubic foot, a mouse in apparently good health was given twelve grains of corn and thirty six grains of wheat. The mouse began eating at once and ate the chit out of one kernel of corn and began eating a second kernel when he suddenly became stupid and was unable to walk without staggering. That the mouse was hungry is evidenced by the fact that it began eating as soon as the grain was placed in the cage and from the fact that it had been given but little food on the preceding day for the purpose of having it hungry enough to begin at once on the grain as soon as it was removed from the gas. Although the mouse lived for several hours it eventually died apparently from the effects of the small amount of grain eaten as it did not eat any more of either kernel of grain nor would it eat cheese or any other material placed before it. In general it was found that if the mice ate the damp grain immediately after taking it from the gas they became stupid and eventually died from the effects. If however the grain was allowed to remain for a time out of the gas before it was eaten, no ill effects seemed to be produced, although the grain did not seem to return to its normal condition as it was never eaten readily after it became perfectly dry. When the mice could be induced to eat it, as they were in several instances, it did not seem at all injurious. It may be concluded, therefore, that the fumigation of dry grains with hydrocyanic acid gas does not in any way injure the grain for food purposes. And even if the grain is damp, it will not be made injurious for food, if it is allowed to air for a short time after fumigating before it is prepared for use.

## SUMMARY.

Dry grains and other seeds may be fumigated with the usual strength of hydrocyanic-acid gas for several days without in any way interfering with the germinating property of the seeds.

Dry grains and other seeds may be subjected for several months to the influence of hydrocyanic-acid gas at the rate of one gram or less of potassium cyanide per cubic foot without entirely destroying the ability of the seeds to germinate.

Dry grains and other seeds subjected to the influence of hydrocyanic-acid gas derived from one gram of potassium cyanide per cubic foot will lose their germinating ability at the expiration of eight months while the same seeds subjected to the gas from one-third of a gram of potassium cyanide per cubic foot will retain their vitality until the expiration of twelve months.

Dry grains and other seeds subjected for from fifteen to sixty days to the influence of hydrocyanic-gas from one-third to one gram of potassium cyanide per cubic foot will hasten germination and accelerate the growth of the resulting seedlings. Although the acceleration continues for several days it does not seem to be of sufficient duration and degree to be of any practical value.

Damp grains and other seeds are much more sensitive to the influence of hydrocyanic-acid gas than dry seeds.

Grains and other seeds soaked twenty-four hours or more will not germinate in gas stronger than three thousandths of a gram of potassium cyanide per cubic foot, whereas if the seeds are soaked but twelve hours, they are able to germinate in an atmosphere containing hydrocyanic-acid gas from fifty-thousandths of a gram of potassium cyanide per cubic foot and in much less time than when soaked for twenty-four hours.

Grains and other seeds soaked for twenty-four hours and then left for seven days in an atmosphere of hydrocyanic-acid gas will remain inactive while in the gas and from seven to twelve days after removal, but will eventually germinate to some extent if the strength of gas used does not exceed fifty-thousandths of a gram of potassium cyanide per cubic foot i. e. hydrocyanic-acid gas is capable of holding seeds in an inactive state for two weeks or longer without destroying their vitality even when the conditions are otherwise favorable for germination.

Dry grains and other seeds treated for several days with hydrocyanic-acid gas of any strength will not be injured for food.

Damp grains and other seeds treated with hydrocyanic-acid gas of any strength even for short periods of time should not be used for food until several hours after removing from the gas. The effect of the gas eventually passes off and the grain may be eaten with safety, although long exposure to the gas seems to render it unpalatable.

*Stored grains and other seeds may be fumigated with hydrocyanic-acid gas of required strength and for sufficient time to insure the destruction of insect pests without injury to the germinating quality of the seeds and without rendering them injurious as foods.*

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# Parturient Paresis—Milk Fever, Calving Fever.

BY SAMUEL S. BUCKLEY.

## INTRODUCTION.

The accompanying pages upon the Schmidt treatment for Parturient Paresis (milk fever) in cattle, are offered because of the remarkable results obtained by the new departure in treatment.

Statistict, prior to its use, placed the nnmber of recoveries from all forms of treatment variously from 40 to 60 per cent.

Reports from 107 veterinarians using the Schmidt method, show 670 recoveries of 670 recoveries out of 775 cases treated—over 86 per cent.

Only seven cases were available for treatment in this neighborhood, and of these, six recovered.

Although the pathology is still obscure, the results of this treatment are satisfactory, and reports have been requested from those adopting this method for further comparison with results from other forms of treatment.

## DESCRIPTION OF DISEASE.

As the name implies this disease of cattle is a form of paralysis associated with the act of calving. It is manifested by general paralysis and loss of consciousness, without well marked post-mortem lesions. With the exception of the "germ" diseases, we have in this, probably the most fatal malady known to cattle.

It is a peculiar affection, especially prone to attack dairy animals, and of these the best members of the herd seem most susceptible. It rarely occurs in cows with their first calves, and not often in old animals—from five to nine years appears to be the critical period. Well fed and especially well bred stock are more liable to the disease than those in poor condition or with indifferent pedigrees. Strangely, too, it occurs after easy delivery and rarely follows difficult labor or abortion.

Sanitary arrangements do not seem to exert any influence upon the appearance or course of the disease.

The cause of parturient paresis has not been satisfactorily determined. Many theories have been advanced from time to time, but none has been wholly acceptable. Among the most recent of these is that of J. Schmidt of Kolding, Denmark, which assumes the disease to be due to the elaboration of a toxin in the udder. His arguments, in a measure, sustain his views, and his success in treatment demonstrates a relationship, at least, between the milk secreting apparatus and the causative factor of the disease.

*Symptoms.*—As already stated this is a form of paralysis associated with the process of calving. It usually occurs within three days after that act. First there may be noticed a vacant stare of the eyes, and slight muscular twitchings over the body. She refuses food and drink, and rumination ceases (loses her cud). She fails to nurse her calf and becomes stupid. Nothing further may develop for six or eight hours. During this period her appearance would not, to an inexperienced observer, suggest a serious termination. After this however, the changes occur rapidly. She indicates uneasiness or perhaps acute pain by an alternate lifting of the hind feet toward the abdomen. She becomes weak and staggers. The weakness increases rapidly and soon she lies down or drops from exhaustion. She may regain her feet once or twice, but eventually she becomes unable to rise. When down she assumes a position which, in itself, is almost characteristic of the disease. Lying upon her breast bone, she bends her neck to the side and places her muzzle upon the flank. If her position be changed she will return her head to the flank. Her eyes become fixed and glassy, her respiration labored. She grates her teeth as if suffering acute pain. Unless relieved these symptoms are followed by depression, extreme weakness and death in from six to twenty-four hours.

Neither the temperature nor the pulse guides one in the severity of the attack.

Complications are apt to appear in prolonged cases. These may be in the form of digestive disturbances due to fermentation of the contents of the stomach and intestines, or diseases of the respiratory organs caused by foreign matter gaining access to the trachea.

As a sequel to this disease we may find a more or less severe attack of Mastitis (Garget), due to injuries to the udder, or perhaps to the unnatural conditions caused by following the Schmidt treatment.

*Treatment:* In as much as the object of this bulletin is to present the Schmidt treatment of parturient paresis for trial, it is unnecessary to review the various methods formerly employed. Statistics gathered during the past two or three years show it to be a very valuable treatment, and it is hoped that the results of the cases treated at the suggestion of this bulleten will be reported in detail to the Veterinarian of the Experiment Station.

Fortunately the necessary outfit for this treatment is inexpensive. It requires a three inch funnel, four or five feet of one-fourth inch rubber tubing and a small glass pipette or milking tube.

The following is the method of procedure:

1. Dissolve 120 grains of Iodide of Potash in one quart of water, which has been boiled, and allowed to cool to about the temperature of the body.

2. Introduce the funnel and pipette into the ends of the rubber tube and place in a bucket of antiseptic fluid, (See Page 2).

3. Milk the udder dry; then place under the cow a piece of oil cloth about a yard square, (a carriage storm-apron may be made to answer) so that the udder will be about the middle of the cloth. Wash the udder

and teats thoroughly with castile soap and warm water, rinsing carefully with antiseptic fluid.

4. Insert the pipette into the end of a teat and fill the funnel with Iodide of Potash solution. By passing successively from one teat to another distribute the solution equally among the quarters of the udder.

5. Rub the udder from the teat towards the body and massage thoroughly in order to distribute the solution throughout.

6. Eight or ten hours after the injection, or when recovery is assured, the udder should be carefully milked out and then bathed with warm water, (about 160 degrees Fahrenheit).

A second injection is rarely necessary; but, if so, it should be done at the end of six or eight hours.

If there should be a tendency toward hardness of the udder or "stringiness" of the milk, baths of warm water should be applied every three or four hours until relieved. If neglected, Mastitis (Garget) will result.

In seven cases treated by the writer, as here indicated, six recovered. Of these, two developed severe cases of Mastitis and one developed a slight "stringiness" of the milk which was easily corrected.

*Prevention:*—As a preventive measure it is advisable to restrict robust animals to a moderate allowance of dry food for a week or ten days previous to the end of their term; and, where there is a tendency toward costiveness or constipation, correct it with a drench of Epsom Salts.

### FORMULAE FOR SOLUTIONS.

Iodide of Potash Solution:

Iodide of Potash (crystals) ........................ 120 grains
Water (previously boiled)........................ 1 quart
(When thoroughly dissolved inject into the udder as described).

Drench for Costiveness:

Epsom Salts,........................ 1 pound.
Ground Ginger........................ 1 ounce.
Water (tepid)........................ 3 pints.
(Give at one dose administered slowly).

Antiseptic solutions:
Creolin,........................ 1 part.
Water,........................ 30 parts.

Thymo-Cresol........................ 1 part.
Water........................ 30 parts.

Chloro-Naptholeum ........................ 1 part.
Water........................ 30 parts.

Any of these antiseptic solutions will answer for this treatment.

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